Science Education Support

The last several years have seen increasing stress in two areas of particular importance in science education: the strong tensions in the interface between science and society, and the mounting demands on educational institutions to serve more effectively an increasingly varied clientele with diverse goals and abilities. The resulting problems of scientific manpower supply and demand, public understanding of science and technology and their implications, and rising costs of science education with no apparent rise in productivity are crucial to the Foundation's education activities.

In fiscal year 1971, these problems led to a range of responses throughout the Foundation's education and resource study activities. In general, focus has shifted from almost exclusive concentration on students likely to major in science and continue to a traditional advanced research degree to the following concerns:

- making professional science education more responsive to current needs;
- fostering scientific literacy generally;
- making science education more effective.

In graduate education, the first steps have been taken in what is likely to be a major reorientation of the Foundation's direct support of education in the sciences at that level. For the past several years, the principal mechanisms for such support have been: fellowships (awards to individuals selected by NSF in national competitions); traineeships (awards to graduate students selected by universities successfully competing for NSF grants); and grants for the support of field training or training in advanced, highly specialized areas—training not generally available in graduate curricula. On a comparative basis, only relatively modest emphasis has been given to the support of projects aimed at improving the educational system itself, e.g., the development of new graduate programs designed to give science and engineering students alternatives to the traditional advanced degrees.

In fiscal year 1971, however, no new traineeships were granted. There were several reasons for this decision. First, it was judged that the supply of conventionally trained graduates with advanced degrees in many fields was in approximate balance with immediate demand, and the need for special incentives to encourage individuals to undertake graduate training looking to research careers in those fields appears to have diminished. Second, other programs and new Foundation initiatives in education were considered to be of higher fiscal priority at this time. A review of the manpower and program priority balance will be maintained. However, NSF continued its traditional program of graduate fellowships, but at a reduced scale, emphasizing further the concept of excellence on which the program is based. The vehicle for support of innovative projects to improve the graduate-level instructional process itself is the Advanced Science Education Program. Funds are provided for the development of experimental courses, new curricula (e.g., alternative advanced degree programs to broaden career options), and training aimed at specific areas of need, such as the environmental field.

The problems of interactions among science, technology, and society are receiving much attention in undergraduate instruction. Student response has stimulated the development of interdisciplinary course sequences to clarify and define some of these problems and work toward successful solutions. A second area of emphasis is the strengthening of additional choices in higher education other than the departmental 4-year science major, e.g., instruction for prospective technicians and technologists, special programs for future teachers of sci-

ence, and upgrading of science instruction in the first 2 years of post-secondary education. Along with improvement in content, changes are also being introduced in the mode of instruction. Audio-tutorial techniques for transmitting information allow the student to work at his own pace, with the instructor available for individual help and tutoring. Even greater choice and responsibility are given to students in the new program of support for Student-Originated Studies, in which the students themselves determine for a portion of their education what they will study and how they will go about studying it.

Pre-college programs continue to stress curriculum reform and actual implementation of improved courses and teaching approaches in the schools. Curriculum development goals at this level include general education in science for the nonscientist with emphasis on individual multi- or interdisciplinary problem-oriented courses, and possible approaches to problems of both horizontal and vertical integration of science education, that is, across fields of science and mathematics and across grade levels. Some completely new approaches are also being explored through a few projects developing science components for new kinds of schools and school organizations, and patterns for outside-the-classroom instruction. The teacher training programs comprise a range of activities varying from courses for individual teachers through the training of leadership personnel to support of comprehensive region-wide plans for the upgrading of a particular aspect of science education. Summer and in-service institutes instruct individual teachers in new curriculum materials; academic year institutes and resource personnel workshops develop master teachers and supervisors able to institute reform programs; and cooperative college-school science projects and comprehensive grants make possible systematic approaches to the problems of improving science education in the schools. Thus, the programs at this level form an interrelated network serving to improve the quality of instructional tools and the capability of the instructors expected to use these tools.

Table 7
Education in Science
Fiscal Year 1971
(Dollars in thousands)

	Number of proposals received	Dollar amount requested	Number of awards	Funds obligated
Graduate Education in Science:				
Fellowships	12,322	$ 80,392	2,497	$15,322
Traineeships	315	106,412	315	19,777
Advanced science education program	179	10,455	79	3,124
Undergraduate Education in Science:				
College teacher program	458	10,459	339	4,905
Science curriculum improvement	168	28,743	118	9,583
College science improvement program	147	21,862	66	5,500
Undergraduate student program	1,559	20,245	502	5,502
Pre-College Education in Science:				
Institutes	1,196	52,081	561	25,873
Comprehensive and systems approach	6	2,465	6	1,466
Cooperative college school science program	439	18,508	158	4,899
Course content improvement	120	15,102	74	6,061
Summer science training	370	6,054	126	1,839
Planning and Policy Studies	47	4,472	38	3,219

The Foundation's program of science resources and policy studies is designed to help provide the framework for the formulation of science policy and effective management of the scientific enterprise. Science resources studies provide a more thorough understanding of the present and long-range issues affected by the status of the nation's basic resources for science and technology—scientific and technical manpower, science education, scientific institutions, the funding of research and development, and the economic impact of research and development. Science policy studies address the identification and analysis of key science policy issues such as the status of science in general and of its numerous disciplines, methodologies and criteria for the allocation of resources, and the dynamics of the research process and its management.

Special projects worked on during this past year related to a number of current issues: unemployment of scientists and engineers; the impact of changes in the rate of Federal funding on academic institutions; a state-of-the-art review of the relationship of research and development to economic growth and productivity; additional work designed to pinpoint the relationship between key scientific events and subsequent technological innovation; and detailed projections of future science and engineering doctorate supply and utilization. Studies of various funding, manpower, and policy issues continue to provide the basis for evaluating the current state of the scientific enterprise.

Table 7 reflects NSF support for educational activities and resource studies in fiscal year 1971.

GRADUATE EDUCATION IN SCIENCE

While the encouragement of innovative patterns in graduate science education became an explicit major NSF goal during the past year, the largest proportion of funds continues to be invested in the development of scientific talent through support of individuals,

Table 8

NSF Fellowship and Traineeship Programs
Fiscal Year 1971

Program	Awards requested by institutions	Individuals involved in applications	Awards offered	Net amount
Graduate traineeships	18,564 (227)[1]	.....	3,458 (224)[1]	$18,044,578
Summer traineeships for graduate teaching assistants	9,110 (215)[1]	.....	926 (208)[1]	1,041,180
Graduate fellowships	.....	9,315	1,972	9,418,229
Postdoctoral fellowships	.....	1,546	185	1,300,000
Senior postdoctoral fellowships	.....	395	54	689,000
Science faculty fellowships	.....	982	214	3,000,000
Senior foreign scientist fellowships	.....	84	72	914,395
Total	27,674	12,322	6,881	$34,407,382

[1] Number of institutions involved.

principally through the fellowship and traineeship programs. Fellowships for U.S. citizens have been available not only to graduate students seeking advanced degrees but also to both young and senior postdoctorals, and experienced faculty members whose teaching responsibilities are primarily at the undergraduate level. In addition, fellowships have enabled a number of distinguished senior foreign scientists to spend up to a year in residence at U.S. universities, where they contribute to the strengthening of the graduate programs of these institutions. A summary of the 6,881 fellowship and traineeship awards made in 1971 is given in table 8.

Another 2,200 individuals—graduate students, postdoctorals, university faculty, and research scientists—attended NSF-supported Advanced Training Projects designed to increase the participants' qualifications in research and teaching. Convened for periods of from 1 week to an academic year, the projects consist of conferences, formal courses and field training programs, and cover a wide range of science disciplines. Examples of projects supported this year illustrate typical kinds of activities:

- Social scientists at the University of Colorado explored population growth, inheritance of behavior patterns, and related problems in a summer training project in the interdisciplinary area of population biology and the social sciences.
- Glaciologists studied the Juneau ice field in Alaska in a summer project dealing with arctic sciences and mountain environments.
- Biologists at the Oak Ridge National Laboratory, Tenn., analyzed the effects of radiation on mammals.

Traineeships

Initiated in 1964 in engineering only and expanded 2 years later to cover all fields of science, the graduate traineeship program peaked in 1968 with a total of 5,656 awards, including 2,211 for beginning graduate students. Its purpose was twofold: to avert a possible shortage of scientific manpower and to attain a wider institutional distribution of student support. The problems that the traineeship program was designed to address appear at present sufficiently well in hand so that a general program to encourage traditional graduate study in the sciences is no longer deemed of prime importance. Hence, except for summer-only awards, no new traineeships were granted this year, and none are planned for fiscal year 1972. The 3,458 graduate traineeships awarded this year covered only commitments from prior years; such commitments will number 1,808 in 1972, and 982 in 1973. The Foundation plans to follow carefully current and projected trends in manpower supply and demand in general and for specific and new fields, as well as the effects of changing support patterns on institutions, so as to institute mediating measures when necessary.

Graduate Fellowships

Although the program of general graduate traineeships is being phased out, NSF plans to continue its program of graduate fellowships, but on a reduced scale and on a restructured basis.

Through this year, 2-year fellowships were offered to new applicants, with the option to apply for renewal of the fellowships. Beginning in 1972, new awards will be offered for periods of 3 years (subject to the availability of funds) only to individuals who will be beginning graduate students or who have had only a minimum amount of graduate training. The second and third year of the fellowship will be approved by the Foundation on certification by the institution of the student's satisfactory progress toward an advanced science degree. Awardees will be required to begin their fellowship activity not later than the fall term following the receipt of the award, but will be permitted to use the remaining 2 years of support within the following 4 years. This will enable them to engage in other approved activities that contribute to their training. Increases in the basic fellowship stipend and in the cost-of-education allowance to the university are also planned.

The number of graduate fellowships awarded in fiscal year 1971 (1,820 awards) reflects about a 25 percent reduction in the level at which this program has been supported during each of the past 5 years. This was necessary as part of a transitional measure toward a reduced total program in fiscal year 1972. Beginning then, about 500

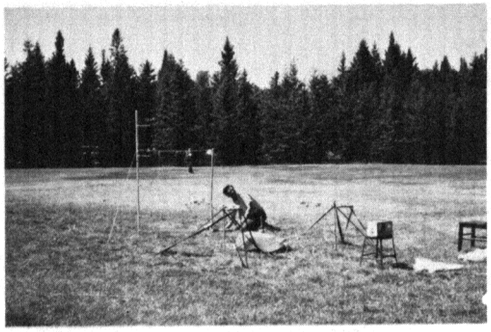
new awards will be made each year, with an estimated total of 1,500 graduate fellows being supported at any given time.

NSF has awarded graduate fellowships, without interruption, since 1952. The program is designed for the support of individuals with the greatest potential for assuring the nation's continued well-being in the sciences. It is the only Federal program available over the broad spectrum of the sciences in which the fellows are selected solely on the basis of ability in a national competition. The reduction in the number of awards and the planned changes in tenure arrangements and financial terms are designed to further emphasize quality over numbers.

Advanced Science Education Program

In addition to its responsibilities for the Advanced Training Projects described above, the Foundation's Advanced Science Education Program (ASEP) supports a wide range of quality-based projects to improve the graduate-level instructional process itself, such as development of experimental courses, new curricula, training aids, and conferences on problems of graduate science education. The Foundation hopes to increase emphasis on this type of support, while reducing programs of primary benefit to individuals. In fiscal year 1971, ASEP awarded 36 grants at a funding level of $1.4 million.

Alternative Degree Programs. Support of the development of alternative kinds of degree programs, which was initiated in fiscal year 1970 with a grant to the SESAME (Search for Excellence in Science and Mathematics Education) program at the University of California at Berkeley, continued this year with three awards. One was made to the University of California at Los Angeles for planning a new program in environmental science and engineering. This new program is expected to lead to a doctorate in 5 years, one of which will be devoted to interdisciplinary problem-solving courses. At the completion of his course work, the student will spend 2 years in applied research at an outside institution—Government, industry, or nonprofit corporation — during which time he will work on practical problems under the supervision of an expert who has agreed with the university to join the student's doctoral committee. After satisfactory completion of 2 years of applied research and the submission of suitable reports, it is anticipated that the student will be awarded the degree of Doctor of Environmental Science and Engineering.



With NSF support, the Committee on Institutional Cooperation, representing 11 universities in the midwest, sponsors a Biometeorology Graduate Training Program to develop proficiency in the use of expensive and sophisticated research tools necessary for ecological studies. Top: Student compares the energy balances of meadow versus forest. Center: Group prepares for measurements of light, temperature, and oxygen profiles in Lake Itasca, Wisc. Below: The turtle is instrumented with thermocouples on a light cable to permit the student to follow thermal regime and calculate its heat balance. (Photos University of Wisconsin)

Another award went to the University of Montana for the development of a new mathematics Ph.D. option. This new option will complement the present program for training research specialists. It is designed to produce competently trained and properly oriented mathematics teacher-scholars to staff undergraduate colleges and work with other scientists on socially important interdisciplinary projects.

The third award in this category was made, in conjunction with a complementary award from the National Institute of Mental Health, to Northwestern University to initiate a pioneering program to produce scholars trained in both law and the social sciences. Upon successful completion of this 5-year program, students will receive both a Ph.D. and a J.D. The first summer for each student will be devoted to special team-research training emphasizing legal issues, while the second summer will emphasize social science content and methodology.

Toward Training Environmental Problem-Solvers. There are several Federal agencies which can provide for the assessment of national environmental problems and/or furnish research support directed toward their solution. There are, however, relatively few agency programs oriented toward the training of individuals who will be competent to serve as future university teachers and/or researchers, or as practitioners or technologists in the environmental field. This has been one of the thrusts of ASEP in the past several years. Some potential researchers and university teachers

can be trained via the research assistant method, as has been done in the past. However, there are almost no programs designed to produce prospective practitioners and technologists in the field, and this type of personnel currently is in short supply. The need to train both future teachers and practitioners for this area of national concern and increasing activity led to nine awards.

Six grants were made in fiscal year 1971 for training in methods of control of pest populations. Five of these involve an interuniversity doctoral training program in an innovative cooperative project whereby all of the students have access to the expertise of the staff and to the equipment and facilities of five centers distinguished for their work on pest population control. The centers are the University of California, Berkeley; the University of California, Riverside; Oregon State University; Cornell University; and North Carolina State University.

Three of the projects are concerned with the advanced education of practitioners, who will be prepared to act as liaison between State or Federal Government personnel, agricultural and industrial producers, and research scientists in universities. Their future jobs will likely involve serving as advisers on the best procedures for solving immediate environmental problems. The particular problems stressed in the projects are acid-mine drainage and disposal of sewage effluent (Pennsylvania State University), marine pollution (Rutgers), and integrated methods of insect pest control (North Carolina State University). These are novel types of graduate degrees in applied ecology; it is expected that the students enrolled will not go on to research doctorates but will terminate at the master's level and then enter on their career jobs in environmental science. For this master's level program, there also exists a cooperative arrangement among the schools for the exchange of students and staff.

Student-Originated Projects. One pilot grant was made during fiscal year 1970 in the category of Interdisciplinary Student-Originated Research Training (ISORT) projects. Even though this activity was not widely publicized, 12 proposals were received from graduate students for consideration during fiscal year 1971, three of which resulted in grants. Seven students sponsored by the University of Oregon are carrying out a seismological, geological, and ecological study of the Galapagos Archipelago. A grant to the Claremont University Center was for an investigation of the skill-transfer ability of aerospace professionals to other fields which will be made by two students whose combined backgrounds include training in industrial psychology, human relations, organization theory, economics, and statistics. The third project is concerned with a study of voluntary birth planning involving 2,000 female subjects between the ages of 18 and 25 in Ingham County, Mich. The birth planning study is being carried out under the direction of two graduate students (one in multidisciplinary social science and one in ecological psychology) and 10 student assistants drawn from the Schools of Human Ecology, Nursing, and Medical Science at Michigan State University.

In funding ISORT projects, the Foundation seeks to provide students with a novel type of training which, if successful, could have a significant impact on tradition-bound graduate curricula. Support for these projects is also a partial response to the growing desire of graduate students to exercise greater independence and stronger initiative in their training.

Experimental Projects

Examples of one-of-a-kind activities include support for training graduate students in the preparation of science courses for nonscientists; an institute for academic law librarians on the social, behavioral, and natural sciences which is designed to help assimilate the literature from these sciences into the curricula of law schools; and an experimental project for re-education of mid-career unemployed scientists and engineers. This last project is designed to test novel approaches in retraining, conversion, and appropriate utilization of the major resource represented by the pool of unemployed scientists and engineers.

UNDERGRADUATE EDUCATION IN SCIENCE

At the college and university level the interactions between science and society are giving rise to marked changes in what is taught, to whom it is taught, and how the teaching takes place. These reactions are in part responsible for the Foundation's decision to expand the target audience of its education efforts to reach that large group of students whose principal interests lie outside of science, and to bring to science students a new awareness of what nonscientists consider important. Coupled with this is an expansion into an area of postsecondary education designed to provide to technicians and technologists the kind of scientific understanding and skills needed to operate the complex technologies of modern society.

In addition, new devices are affecting the way in which the sciences as well as other subjects are taught, making possible increased use of a variety of new instructional modes such as self-paced instruction. Thus, in science education the Foundation is supporting experiments ranging from sophisticated machine-based instructional systems to those in which the student plays a major role in determining the method and the pace of the instruction.

Changes and Improvement in Content

Three projects concerned with providing meaningful instruction on problems of science and society are receiving Foundation support: (1) the Project on Science, Technology, and Society, at Cornell University; (2) the development of an Interdisciplinary Curriculum in Environmental Studies, at Dartmouth College; and (3) the Project to Build Educational Bridges Between Science and the Humanities, at the Rensselaer Polytechnic Institute (supported jointly with the National Endowment for the Arts and Humanities). In these programs, courses at the introductory level are focused on the entire undergraduate population, not just the science and engineering majors. The content is broad and exploratory, emphasizing the strategies by which explicit and manageable problems within complex societal settings are identified, and the intellectual resources necessary to attack them are marshaled. Typical course topics are social implications of engineering, biology and society, earth as an ecosystem, human dimensions of environmental problems, resources and man.

Upper division courses rely on the skills and information acquired through studies in the classical disciplines, and take advantage of diverse backgrounds in a series of problem-oriented workshops. For instance, the Cornell seminar on Technology Assessment will bring together upperclass and graduate students of engineering, the physical sciences, sociology, and law. Rensselaer's project will include an emphasis on the long-range viability of man's society, and will engage students from the humanities and from engineering and science in an analysis of concepts of social and economic progress.

The same themes of science-technology-society and interdisciplinary studies run through many of the summer institutes for college teachers. At the Catholic University of America, R. J. Seeger's group is dealing with interdisciplinary approaches to the solution of contemporary problems, especially those arising in the life, environmental, and social sciences. At Colorado State University, J. Forbes McClellan presents an approach to botany, zoology, ecology, and geology which integrates these fields through study of their interrelationships occurring in the natural state.

Related to this trend is the melding of mathematics and computers with the social sciences, again reflected in the orientation of a number of summer institutes dealing with such topics as Quantitative Methods in Sociology (Loyola University, Chicago), Mathematical Psychology (University of Michigan), and Mathematical Applications in Political Science (Virginia Polytechnic Institute). Current trends in the social sciences are also influencing the subject matter of summer institutes, as illustrated by projects in Mass Political Communication (Ohio University), Urban Economics (Stanford University), and Linguistics, Logic, and Philosophy (University of Connecticut).

Summer activities informing college teachers of recent developments in such areas as Digital Computers in Chemical Instrumentation (Purdue University), Ocean Engineering (University of Rhode Island), Primate Behavior (University of California at Davis), and Models of Urban Spatial Structure and Ecology (Ohio State University) help assure that the content of courses and curricula will be kept up to date.

About 2 years ago, the Foundation began laying the groundwork for a program to develop an additional option in higher education, namely, the training of technicians and technologists. Projects to produce needed course materials are under way in electronics, chemistry, biology, and physics. The projects in biology and physics are the most recent. Both will produce an array of instructional modules from which the instructor can select those best adapted to his needs. The projects are national in scope, and involve widespread testing of the materials before a final version is prepared. The biology project plans some 100 modules; the physics project, 20 modules produced at four different cooperating institutions.

An experimental grant of $77,000 designed to test the feasibility of institutional support for technician education was made to Charles County Community College, La Plata, Md. This college has instituted a pioneering curriculum to train technicians in the complex physical, chemical, and biological factors of estuary environments. Twenty-five students will enter the program in the fall of 1971. At the end of 2 years of successful work, they become eligible to receive the Associate of Arts degree in estuarine resource technology.

The technician education program is further bolstered by summer institutes at Rochester Institute of Technology and at Wentworth Institute which provide special training for 55 persons who teach electrical or mechanical technology.

With the announcement of the Technician Education Development Program, the implementation of improvements in specific institutions has begun. Institutions with technician training programs have responded quickly, and the Foundation expects to make this program fully operational during the coming year.

Changes and Improvements in Modes of Instruction

Self-Paced Instruction. Increasingly, the trend toward self-paced instruction is influencing science education in colleges and universities. Students vary tremendously in their maturity, degree of interest in academic work, preparation for college-level study, and motivation. Self-paced instruction appears perhaps

the most practical means for accommodating to differences among students. Rapid advancements in instructional technology have given added impetus. Instructors are likely to adopt, and students will quickly accept, tools which promise to remove from the classroom and put under the control of individual students the requisite amount of drill on factual material. Thus, self-paced instruction also helps reduce tedium for both the teacher and the student.

Self-paced instruction takes a variety of forms. Among the best known is the audio-tutorial scheme which is spreading widely from its center of development in the Division of Biology at Purdue University. Created initially by S. N. Postlethwait as an aid in teaching plant science, the approach has been adapted to courses in a variety of disciplines throughout the country and uses a wide array of techniques for transmitting information. The bulk of the instruction occurs in a semiprivate setting with a resource person always available, and involves self-testing and advancement to the next unit when the student has mastered each preceding one. The instructor is freed to a large extent from routine chores of teaching and is available for the kind of personal interaction with students associated with the tutorial mode of instruction.

With support from the Foundation, Dr. Postlethwait is now engaged in packaging for use by other institutions a broad program of instruction in biology. Each package or "minicourse" contains all the basic instructional materials needed by a teacher in presenting a given topic, and so arranged as to encourage individual modification to meet the requirements of a specific teaching situation.

Another variation is the so-called Keller method, utilized by Ben Green of the Education Research Center at MIT, which involves self-pacing on the semester scale rather than a weekly schedule as used by Dr. Postlethwait. The Keller method depends more heavily on written materials and does not make use of the regular group meetings which characterize the Postlethwait procedure.

Student-Originated Studies. Recognizing the role of the student in determining what he will study, the Foundation has initiated a program of support for student-originated studies to:

- encourage college students to express in productive ways their concern for the quality of the environment;
- provide support for groups of college and university students who can demonstrate their readiness to assume increased responsibility for their own educational development.

Students, both undergraduate and graduate, in groups generally of five to 15 persons, submit proposals describing the scientific or technological studies they wish to carry out and the costs involved. Key features of the projects are that they should be student-originated, student-planned, and student-directed interdisciplinary studies dealing with a problem or set of associated problems related to the environment—physical, biological, or social. The host institution, in each case, is a 4-year college or university, and a faculty member is designated project advisor, but the students and the student project director carry full responsibility for the work. The projects occupy the student participants full time for a period of 10 to 12 weeks.

In fiscal year 1971, 560 student groups submitted proposals, with all States except Arkansas and Montana represented. Undergraduate students were invited to serve as panel reviewers with full voting rights, a first in NSF procedures for proposal evaluation. Each panel also included four scientists or engineers, generally faculty members, one each representing the biological sciences, physical sciences, social sciences, and engineering. The $1.5 million allocated was enough to fund a total of 103 proposals from 97 institutions in 47 States and the District of Columbia, providing support for 1,102 participants. Even so, there were 185 meritorious proposals requesting $2.67 million for the support of 1,892 participants for which funds were not available. In an unprecedented move, the Director of the Foundation issued Letters of Honorable Mention to these 185 student groups, with copies to State governors and institutional heads. Several honorable mention recipients have successfully used this testimonial to piece together enough local support to go forward with at least parts of their planned projects.

Bringing Institutes to Teachers. For a number of years, the Foundation has supported summer institutes and short courses to give college teachers an opportunity to study recent trends in various disciplines with leading scientists. Typically, the faculty members were brought to a major campus where the institute or short course was being held. Last year the Foundation began experimenting with a different format in which leading scientists spend 2 days at each of a number of different centers within easy commuting distance of a substantial number of colleges. The scientist introduces his subject using whatever techniques of presentation he favors, and leaves with the teachers (his students) an array of reading assignments and homework pending his second visit several weeks later. At the second meeting, questions are discussed in the light of what has been learned, and loose ends are pulled together.

Experience with the trial projects suggests that this scheme is highly cost-effective. Travel and subsistence for participants are greatly reduced, the participants have an opportunity to study and reflect on the material at their leisure, and the plan ensures multiple exposure rather than the concentrated one-shot ses-

sions of conventional short courses. These new-style short courses are being expanded during academic year 1971–72. Through a grant of $586,000 to the American Association for the Advancement of Science, 12 field centers have been established, organized into three "circuits" of four centers each. Eleven courses have been arranged on such subjects as human genetics and societal problems, air pollution, and computer techniques for natural and social science faculties. More than 2,700 college teachers are expected to participate in these courses.

Instructional Technology. The computer continues to play a predominant role in technological support of instruction but, while powerful, it is not alone in this field. The instructional film still has its place. For example, cultural anthropologists are interested in a recently completed film on primitive tool-making in which the unique expertise of anthropologist Donald Crabtree in flintknapping was recorded by a team at Idaho State University.

The advent of relatively inexpensive and easy-to-use video equipment is bringing new competition to film for use in instruction. Video tape is especially useful to those who wish to prepare informal, on-the-spot illustrations of laboratory methods, procedures, or special phenomena. The ready playback and erasure capability enables both instructors and students to record, evaluate, and rework materials with minimum delay and expense. There are problems to be solved, such as incompatibility of various makes of video equipment, the high cost of color video, and development of a more general understanding of the potential and the limitations of the medium. Yet video is making a very strong bid for an important place in education.

An exceptionally advanced system in instructional technology is operated by the North Texas Association for Graduate Education and Re-

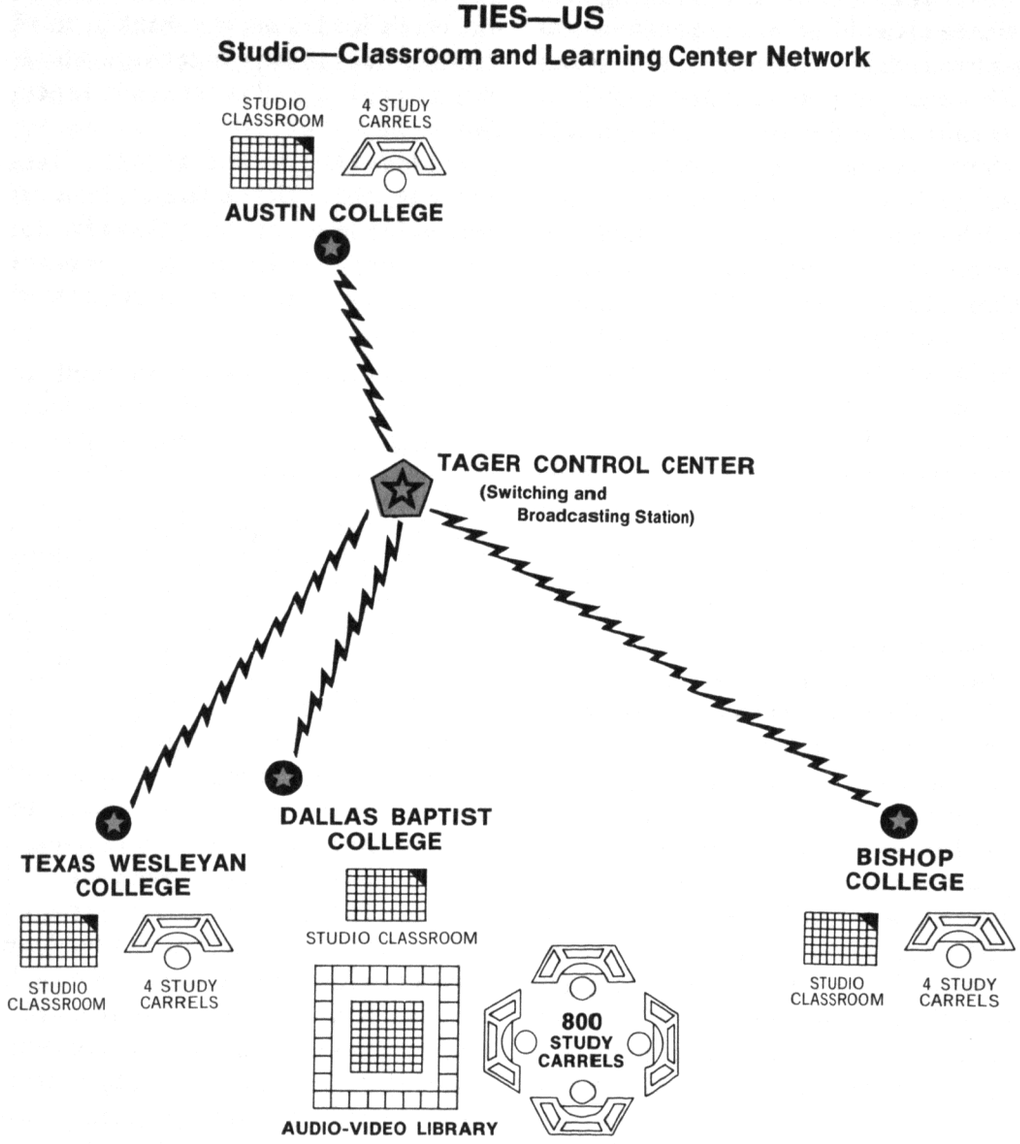
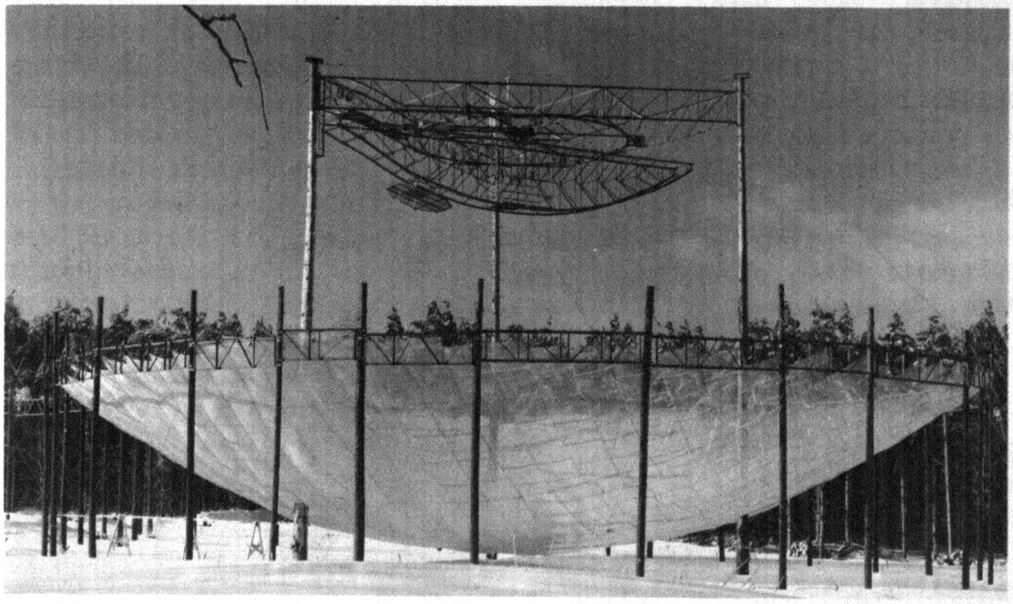


Table 9

COSIP Section C Fiscal Year 1971
Cooperative Projects for 2-Year Colleges

AWARDS BY DISCIPLINE

Discipline	Number	Amount	Percent of Total $	Number of Departments
Biology	6	$254,000	17	60
Chemistry	6	317,900	21	96
Engineering	3	192,600	13	22
Environmental Sciences	0	0	0	0
Mathematics	6	160,000	11	53
Physics	4	205,200	14	86
Social Sciences	4	224,100	15	103
Interdisciplinary	2	122,900	8	67
Multidisciplinary	1	17,600	1	7
	32	$1,494,300		494



First antenna of the Five Colleges Radio Astronomy Observatory. The wire mesh surface is supported by cables and 26 utility poles. The central feed structure is supported by three 70-foot poles and is steerable in both azimuth and elevation. (Photo NSF)

Students raise a 70-foot pole for the feed support structure of the fourth antenna for the Five Colleges Radio Astronomy Observatory. The first antenna, completed and in operation, can be seen at left. (Photo NSF)

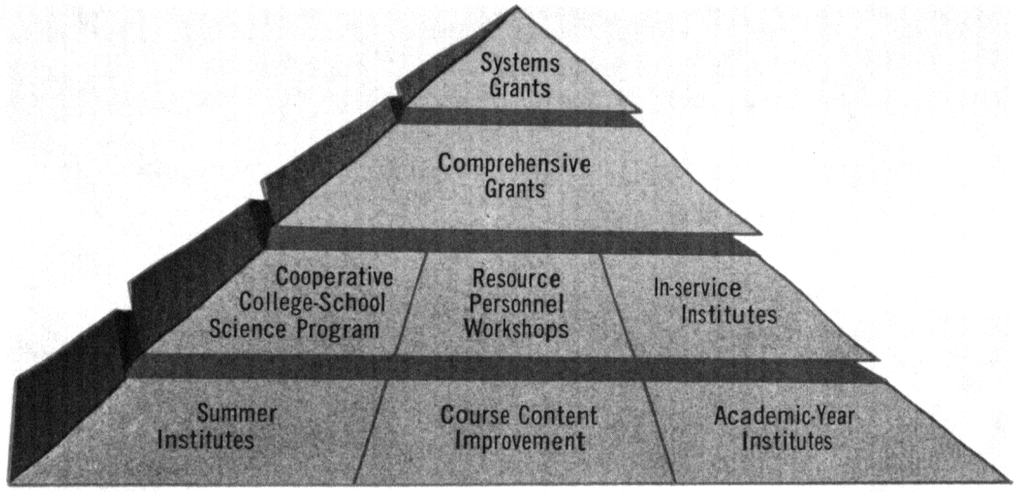
search (TAGER). The Dallas Baptist College has been added to the group of institutions making up the Tager Institute for Environmental Studies in Undergraduate Science (TIES-US), thereby bringing to the group a learning center with over 800 individualized audio and video carrels located in a unique library-conference faculty office building. The grant provides for a marriage between the traditional academic expertise at the previously supported institutions (Bishop College, Texas Wesleyan College, and Austin College) and the advanced methodology of Dallas Baptist. Not only is the electronic classroom extended to the new institution, but each of the other participating institutions is now connected to the 20 video and 100 audio channel "electronic library" at Dallas Baptist. The project offers the prospect of marked economy in professional staff time through the use of advanced mechanical and electronic tools coupled with carefully designed curricula.

Cooperative Activities. Through its program of Cooperative Projects for 2-year Colleges, the Foundation seeks to enliven and strengthen science instruction and to help smooth the transition into advanced education for the student who begins his higher education at a 2-year institution. This program has now had an effect, in one or more subject-matter areas, in slightly over half of all 2-year colleges in the nation. In fiscal year 1971, it reached into nearly 500 departments in nine disciplinary areas. Table 9 shows awards by discipline for fiscal year 1971.

One project, supported prior to fiscal year 1971, deserves comment because it is now nearing completion. With the cooperation of such funding groups as the Research Corporation, Sloan Foundation and others, a group of five New England colleges (Hampshire, Amherst, University of Massachusetts, Smith, and Mt. Holyoke) has developed a high-quality radio telescope facility for use by undergraduates participating in the "Five Colleges Astronomy Project." The accompanying photograph of the nearly completed telescope serves to emphasize that this is a facility which most predominantly undergraduate institutions could not realistically support, either financially or academically. By pooling resources, however, an economical and very high-quality program can be made available to undergraduate students.

PRE-COLLEGE EDUCATION IN SCIENCE

With the exception of the Student Science Training Program aimed directly at high school students, Foundation programs at the pre-college level emphasize the development of improved instructional materials and patterns, together with a coordinated effort to assist instructors and school systems to put resulting reforms into practice. The interrelationship between programs is represented schematically in the accompanying figure. There is no sharp boundary between the layers, nor between activities in a given layer. The base layer provides new tools of instruction and in-depth studies of new curricula. The institutes also develop leadership capabilities for implementation activities. The second layer introduces implementation in schools through the Cooperative College-School Science (CCSS) projects, as well as in-service institutes, which may be focused on implementation or teacher education, or both. An implementation project may involve institutes, a Resource Personnel Workshop, a CCSS project, regional agencies or institutions, or various combinations of these. Both comprehensive and systems grants are new activities designed to extend the impact of local implementation. Table 10 summarizes the extent of Foundation efforts for in-service education of teachers.



One purpose of the Student Science Training Program is to bring outstanding students into contact with research scientists. In this picture, students and instructor participate in the study of aquatic biology at Rattlesnake Creek, Mont. (Photo University of Montana)

Case Histories

An example of the variety of interactions just described is the Intermediate Science Curriculum Study, a 3-year sequence developed at Florida State University with joint support of the Office of Education and the National Science Foundation. The seventh-grade materials have been published in a commercial edition and used this past year by approximately 100,000 students in 47 States. The content is organized around the twin themes of energy, its forms and characteristics, and measurement and operational definition. Organizing themes for the eighth grade are matter and its composition, and model building. The ninth-grade course is designed to synthesize and extend the investigative experience and knowledge gained up to that point and to apply them to problems of practical and scientific significance.

The Foundation has supported the development of the eighth- and ninth-grade materials, and the dissemination of information, teacher training, and other implementation. Nine Resource Personnel Workshops have been supported in the past 4 years, extending leadership training to 308 individuals. Twenty-one projects supported in the past 3 years through the Cooperative College-School Science Program have provided a total of 468 training op-

Table 10

Pre-College Education in Science Teacher Education Activities

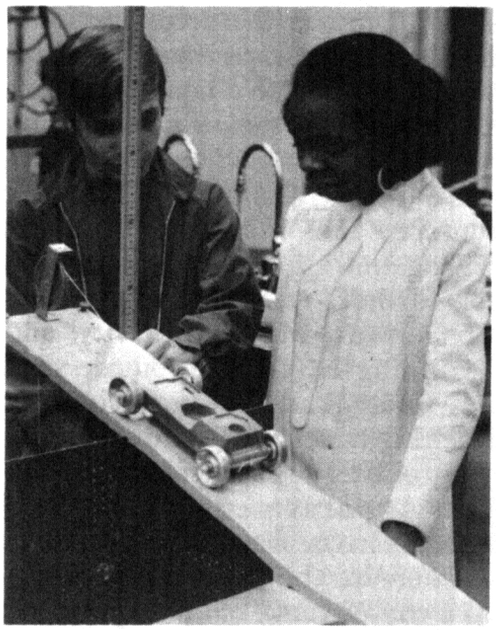
Program	Fiscal Year 1970			Fiscal Year 1971		
	No. of Grants	No. of Partic.	$ Amt. Granted	No. of Grants	No. of Partic.	$ Amt. Granted
Summer Institutes	464	19,500	$23,300,000	459	19,618	$23,300,000
In-Service Institutes	348	24,021	5,214,917	222	11,780	970,612
Academic Year Institutes	64	1,530	8,421,014	28	444	1,296,188
Comprehensive and Systems Approach	....	.....	.....	6	1,444	1,561,291
Cooperative College-School Science	136	6,309	1,760,000	158	2,684	4,729,900
Resource Personnel Workshops	53	2,078	4,654,421	43	1,726	1,690,000
Totals	1,065	53,438	$43,350,352	916	37,696	$33,547,991

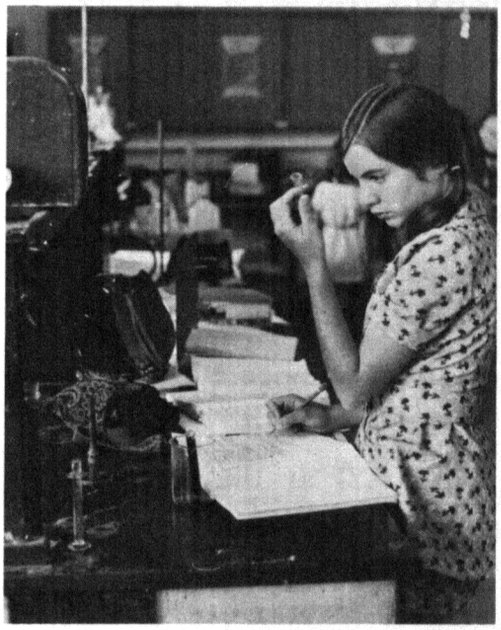
portunities. Nine Summer Institutes conducted in 1970 and 1971 have trained 355 teachers, and 11 In-Service Institutes in 1969, 1970, and 1971 have included 415 participants.

Another illustration is provided by the combination of projects initiated by a science supervisor in the school system of San Antonio, Tex., as a result of attendance at a summer conference on new science courses developed with NSF support. Through consultation with Foundation staff and the University of Texas, San Antonio school officials mapped out a general strategy for implementing the changes they desired, with NSF support to be used only where local funding was unavailable or insufficient. Among the existing resources pooled were NDEA funds (Office of Education) for science equipment, new course materials already available, and teachers who had attended NSF Summer and In-Service Institutes in biology, chemistry, and earth sciences. Very helpful relationships were established with local colleges —Trinity University, Incarnate Word College, and University of Texas. These resources were organized into several CCSS projects, beginning with the senior high schools. Results were:

- Biology—adaptation of BSCS* to all language groups in the schools, particularly Mexican-Americans.
- Chemistry — adoption of CHEMS** in the local area and State-wide adoption for Texas.
- Physics—spreading of PSSC***, increased professionalization of physics teachers.

The junior high school shows similar results, with CCSS projects organized around teachers who had already received good background through institutes and who were now accepted as leaders. Thus, grades 8 and 9 have NSF-supported science courses as the standard curriculum. Now a massive attempt for the elementary schools is being mounted for dissemination of *Science—A Process Approach* entirely with school system resources, together with an experimental joint effort with the University of Texas to develop integrated elementary mathematics-science based on the same curriculum but taught in each school by specially trained teacher specialists. In this last project, a Resource Personnel Workshop at the University of Texas and a Cooperative College-School Science project





The Intermediate Science Curriculum Study is a 3-year sequence developed for students in the 7th, 8th, and 9th grades. The content is organized around the themes of energy, its forms and characteristics; matter and composition, and model building. (Photos Florida State University)

*BSCS — Biological Sciences Curriculum Study

**CHEMS — Chemical Education Material Study

***PSSC — Physical Science Study Committee

These are major NSF-supported curriculum reform groups having developed multimedia courses in the three disciplines.

are closely linked, with participants in the former providing leadership and training for the inner-city elementary school teachers involved in the latter.

Similar patterns can be found on a somewhat lesser scale elsewhere, for example, in Memphis, San Diego, Northern Louisiana, Philadelphia, the Denver-Boulder area, and Portland, Oreg.

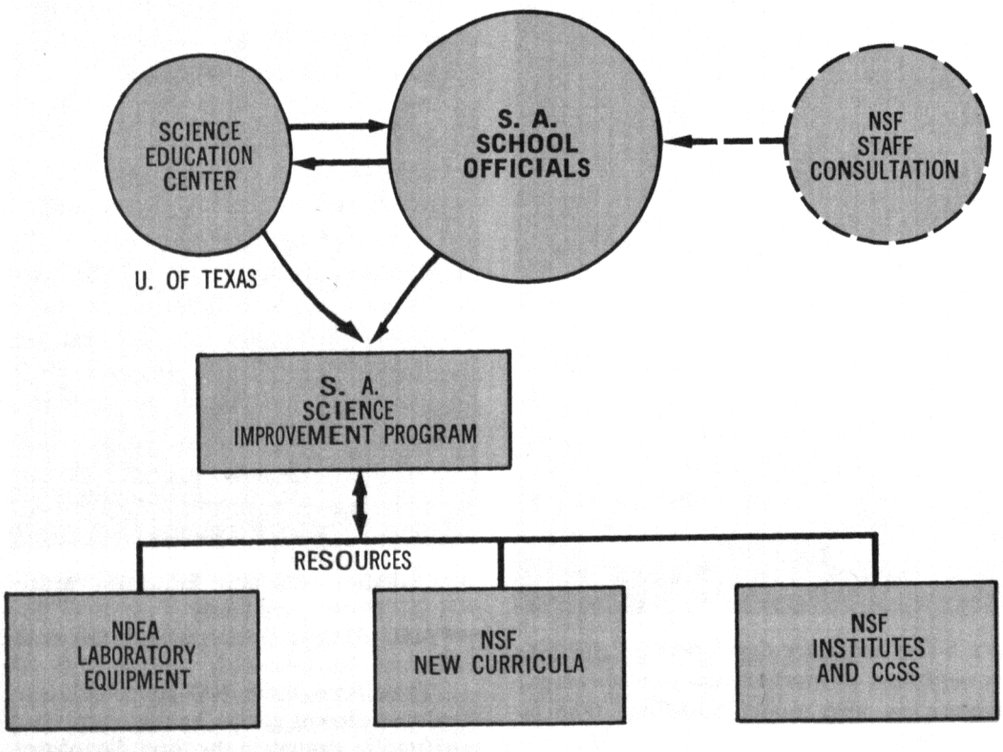
Institute Programs

In the appropriation act for fiscal year 1971, a large proportion of funds for in-service education of teachers was earmarked for support of summer institutes for secondary school teachers. As a consequence of this, Academic Year Institutes (AYI) had to be limited to projects providing leadership and supervisory training. Such projects could have a "national orientation"—drawing participants for leadership training from the country as a whole—or a "regional orientation" focused on a service area around the host institution. Of those in the first category, the AYI at the University of Wisconsin is a good example. Ten science teachers and 10 mathematics teachers who have strong academic and teaching records, hold master's degrees in science or mathematics, and are interested in supervisory training are selected nationally for a full calendar year of advanced work at the University of Wisconsin. During this time, each participant spends a semester of supervisory internship in a selected school system, which may be in one of the larger city systems in Wisconsin or be in association with one of the Cooperative Educational Service Agency (CESA) districts in that State. The other semester and the related summer are spent in academic work relevant to supervision, but concentrating on the participant's specific discipline. The cooperating school systems contribute substantially to the project.

The AYI at the University of North Carolina is representative of the second or regionally oriented type. This project involves an interrelated mix of three categories of participants from North Carolina: experienced teachers, intern teachers, and undergraduates who are preparing to become teachers. Twelve intern teachers, after spending a summer and a semester in residence, will be formed into six teams, each of which will replace an experienced teacher who will then return to the campus for a full semester of study. During the preceding summer, the six experienced teachers will have been on campus for one of the summer sessions, interacting with the intern teachers who will replace them. During the following summer, the experienced teachers will again be in residence on campus for further work in the program. Concurrent with this activity, and beginning in their sophomore year, six undergraduates preparing for teaching careers will be involved in progressively more responsible positions as paraprofessionals, working with the interns and the experienced teachers in the cooperating schools. As a consequence of this experience, their awareness of the practicalities of teaching as a career and their dedication to the profession should be enhanced.

A wide variety of opportunities for part-time or short-term, full-time study for secondary school teachers without stipend support is included in the In-Service Institutes Program. These activities are characterized by a specific local orientation and a low relative cost. By encouraging the use of off-campus sites which often makes it more convenient for the teachers to attend, In-Service Institutes have the potential of reaching a larger fraction of the teachers than other teacher education activities. Every effort is made to encourage innovative activities and broaden the scope of the program, particularly in such areas as the social sciences and technical education. For example, the institute at Queens College, New York, will introduce 40 teachers in

SAN ANTONIO SCIENCE CURRICULUM IMPROVEMENT



greater New York to sociology and Sociological Resources for the Social Studies materials and teach them to conduct in-service training among their associates in area schools. This use of the "multiplier effect" will be an important component of any effort to reach a substantial fraction of the total teacher population.

Projects in the Summer Institute program range through all the scientific disciplines, with emphases on leadership training through sequential institutes and on use of new curriculum materials. Approximately one-fourth of the institutes for the summer of 1971 were based on new curriculum materials developed through Foundation grants, and another fourth had components involving these materials to a lesser degree. An innovation introduced in the Summer Institute program is exemplified by five projects in which groups of participants from a particular school attend the institute to develop and adapt course material for use in their own classes when they return to school. One such project enrolled 20 participants in teams of two to five teachers from a single school. Admission to the institute was based on the merits of proposals from the teacher groups for the summer's work, with the period of participation varying from 6 to 10 weeks. The staff of the Education Research Center at MIT provided support, guidance, and facilities for the participants in the institute.

New Patterns in Teacher Education

The two top layers of the figure on p. 74 represent new ways to organize teacher education, both initiated in fiscal year 1971. Activities include both pre-service and in-service teacher education components and place strong emphasis on interaction with schools in the region of the host institution to help meet their needs. Five Comprehensive Grants were awarded in fiscal year 1971 to the University of Mississippi, University of Notre Dame, San Jose State College, the University of South Dakota, and the University of Wyoming.

The Comprehensive Project at the University of Wyoming is a good example of this new program. The University of Wyoming has been continuously engaged in teacher education activities since 1954. These activities have increased the university's interest in the education of secondary school teachers of science and developed a close working relationship between the university and the high schools of the State. Through the Comprehensive Project, a system of "portal schools" will be developed throughout the State to serve as centers where teachers will be trained in the use of newly developed curricula and materials. Conducting these in-service programs will be teachers who will have been trained in summer and academic year programs at the university. The "portal schools" will also provide prospective science teachers with the opportunity to work under the guidance of a master teacher. An associated intern program for post-baccalaureate certificated teachers will permit both the interns and the experienced teachers whom they will in part replace to acquire appropriate advanced training. Also part of the program are a distinguished professional chair in science education, extension of activities to neighboring States, and a science teaching center to serve as library, research center, and coordinator of project activities.

The systems approach, represented at the top of the tetrahedron on page 74, attempts to focus the now more or less independent educational efforts of Federal, State, and local government, and of private agencies on regional science education needs. In this context, a system is defined as an integrated group of interacting agencies, designed to carry out a predetermined function. The agencies in question may include institutions involved in the education of science teachers; a State department of education, other State and Federal agencies; cooperating school districts; private foundations, and industrial and business organizations. The function to be performed is to be expressed in terms of objectives and related to the overall plans for science education in the region.

The first experimental grant for this approach was awarded in fiscal year 1971 for the Del Mod System, a State-wide coordinated project in Delaware planned cooperatively by the University of Delaware, Delaware State College, Delaware Technical and Community College, the Delaware State Department of Public Instruction, the school systems of Delaware, the DuPont Company and the National Science Foundation. It is organized around two concepts: Science Resource Centers and Science Education Field Agents. The four Science Resource Centers will serve as focus for various aspects of in-service and pre-service teacher education, as sources of materials, and as bases of operation for Science Education Field Agents. The Science Education Field Agents will provide liaison between the institutions of higher education and the school systems in roles somewhat similar to County Agricultural Agents, having major responsibility for in-service education and for implementation in the schools. Around these key concepts will be built a comprehensive mix of activities for in-service and pre-service teacher education, including the development of curricular materials in marine science and population studies, with related curricular changes and new teaching strategies in the classrooms of the schools in the State. The implementation phase has been planned in close consultation with the 26 school systems in Delaware whose cooperative involvement will increase as the project develops. Attention will also be devoted to technical education, initially through the development of a science education technician program at Dela-

443-979 O - 72 - 6

ware Technical and Community College. In the first phase of the project, the major thrust will be science in the middle schools, with expansion to include the role of mathematics in science (a pilot mathematics project is included in the first year), and eventually science and mathematics, kindergarten through 12th grade. A continuing and substantive program of testing and evaluation, starting with the collection of base-line data and designed to measure changes in both achievement and attitude, will be an integral part of the project.

An example of experiments developing new approaches to science education is a project at Hahnemann Medical College in Philadelphia. Fifty high-ability high school seniors devoted full time during the 1970–71 academic year to an organized curriculum of research participation and independent study in the biomedical sciences under the guidance of research scientists of Hahnemann. To fulfill 12th-grade requirements, they also attended seminars and lectures in English and history; time was allotted as well for an elective subject and a physical education course. By arrangement with the State Department of Public Instruction and local school systems involved, the students graduated with their respective high schools in June 1971. A number of colleges and universities have agreed to admit these students to their sophomore class upon completion of the Hahnemann program and thus eliminate the freshman year of college study. Further experimentation of this kind is planned to develop increasing flexibility in pre-college science education.

SCIENCE RESOURCES AND POLICY STUDIES

Sciences resources and policy studies are conducted by the Foundation through periodic surveys and special analytical studies undertaken to meet the needs of the Foundation and other Federal groups. These study activities are also of service to State and local government bodies, the nonprofit sector, industry, and the general science community.

Staff studies and analyses are supplemented with a program of grants and contracts conducted mainly with universities, other nonprofit organizations, and other Government agencies. In fiscal year 1971, the Foundation published 31 resources and policy reports, while another 19 were the product of NSF-financed grants and contracts. Following are highlights of some of the more significant science resources and policy study activities of the past year.

Science Resources Studies

Manpower

Employment-Unemployment of Scientists and Engineers. In the spring of 1971, more than 3 percent of the engineer work force and as many as 45,000–65,000 scientists and engineers were estimated as unemployed. Scientists and engineers represent a relatively small portion of the total labor force of more than 85 million, yet the loss of their professional contributions to the nation's welfare is a serious matter. Since they do represent a small group, special surveys and studies are necessary to secure accurate data on the extent of unemployment and the characteristics of the unemployed.

The Foundation provided support to the National Research Council for the second year to conduct a survey of academic departmental chairmen on the employment status of 1969 and 1970 Ph.D. graduates in science and engineering. Over this period, the proportion unemployed and seeking employment increased from 0.5 percent of the 1969 graduates to 1.1 percent of the 1970 group, and the proportion considered underemployed rose from 0.7 to 1.2 percent. Also in fiscal year 1971, with financial support shared with the Departments of Defense and Labor, NSF undertook special surveys of the employment status of scientists and engineers. Information on scientists was obtained through a survey of more than 300,000 scientists who had previously responded to the 1970 National Register of Scientific and Technical Personnel. Of all scientists responding to the survey as of spring 1971, 2.6 percent were unemployed compared to 1.5 percent in spring 1970; the rate for doctorates was 1.4 percent in 1971 compared to 0.9 percent a year earlier, while the rates for nondoctorates were 3.5 and 2.9 percent respectively. A similar survey of engineers was in process at the end of the year.

Science and Engineering Doctorate Utilization. During the past year, in the report *Supply and Utilization of Science and Engineering Doctorates, 1969 and 1980,* the Foundation updated its previous analysis of the future supply and utilization of science and engineering doctorates.

The new projections show that as many as 315,000–336,000 doctorate scientists and engineers may be available by 1980, compared to 270,000–297,000 available positions. This represents a greater likelihood of a future oversupply than the previous NSF projections developed 2 years earlier. Furthermore, wide differences in the various broad areas of science were indicated, with some serious potential imbalances signalled for engineering and the social sciences.

The study also points to some probable changes in the pattern of utilization over the next decade. Although about two-thirds of all science and engineering doctorates in 1969 were engaged in teaching and research in graduate schools or employed in nonacademic R&D positions, only one-half of the new doctorates entering employment in the 1970's are expected to be in such positions. The other half are projected

to be teachers of undergraduates or in non-R&D positions outside the academic world.[1]

National Register of Scientific and Technical Personnel. The 1970 canvass of scientists will be the final one of a series dating back to 1954 because the maintenance of a list of scientists for purposes of locating individuals with specific characteristics is no longer essential, and the use of samples instead of full coverage promises relatively small savings. Resources will be available in fiscal year 1972 to explore and develop alternative methods for securing required information on scientists and engineers.

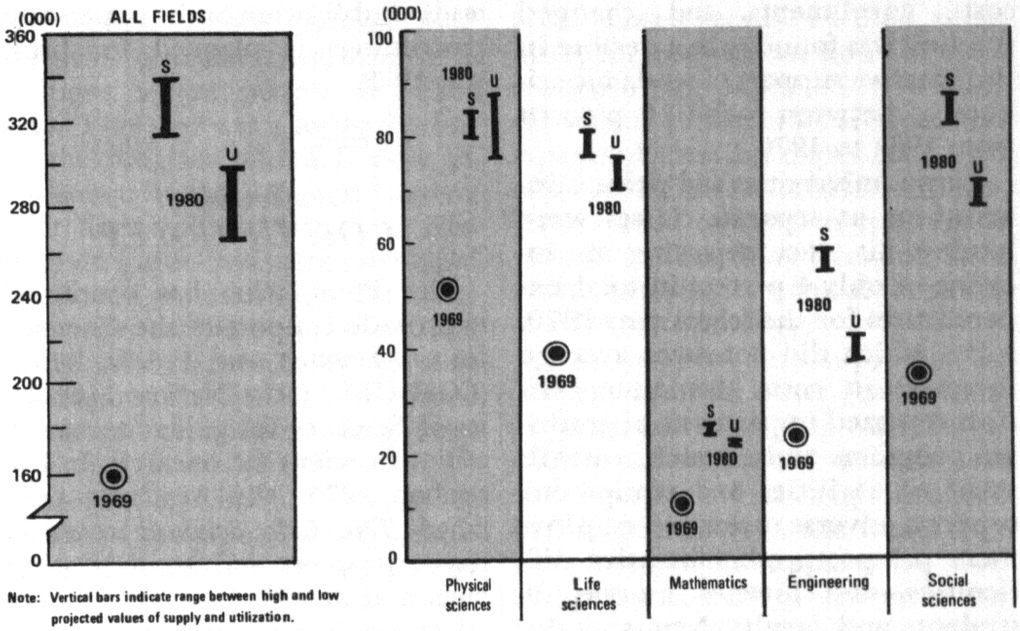
Research, Development, and Academic Science Expenditures

Federal R&D Funding by Budget Function. A new Foundation report, *An Analysis of Federal R&D Funding by Budget Function, 1960–72,* compares Federal R&D expenditures in the period 1960–72 for 12 budget functions (i.e., health, defense, etc.) with total Federal outlays for each function, analyzes trends and developments, and describes current R&D programs.

Federal expenditures for research and development have experienced a reduction in priority since the mid-1960's when compared with total Federal expenditures. From 1960 to 1965, the share of total Federal outlays representing R&D expenditures rose from 8.5 to 12.4 percent. As the total Federal budget has increased, the proportion allocated to research and development decreased each year to an estimated 7.4 percent share in 1972, the lowest in the entire 1960–72 period.

National defense, space research and technology, and health have represented the chief areas of Federal R&D funding throughout the 1960–72 period. In 1972, these functions are expected to make up 86 percent of the estimated total R&D expenditures of $15.7 billion.

SUPPLY AND UTILIZATION OF SCIENCE AND ENGINEERING DOCTORATES, BY BROAD AREA OF SCIENCE, 1969 and 1980



Note: Vertical bars indicate range between high and low projected values of supply and utilization.

Source: National Science Foundation

Federal Support of Higher Education. The Foundation is the implementing agency for the Committee on Academic Science and Engineering of the Federal Council for Science and Technology and is responsible for collection and analysis of data on Federal funding of academic activities. Federal agencies reported to the Foundation that their obligations to universities and colleges for both science and nonscience activities totalled $3.2 billion in 1970. This was nearly 7 percent below the 1969 funding level, the lowest level of Federal support since 1966, and the first decrease, in actual dollars, in direct Federal funding since 1963, the first year for which these data are available. In *Federal Support to Universities and Colleges and Selected Nonprofit Institutions, Fiscal Year 1970,* the National Science Foundation reported that the greatest impact of this reduction occurred in academic science support which decreased some 8 percent from the previous year's amount compared to a 3 percent reduction in the funding of nonscience activities. Federal funds obligated for academic research and development, including R&D plant funds, declined nearly 4 percent.

The results of two other surveys showed that expenditures of funds for academic science—both research and education—from all sources increased by 7 percent and 8.5 percent in the school years 1969 and 1970, respectively, but failed to keep pace with increases in college enrollments and costs. The academic institutions in these two surveys provided financial information in terms of expenditures while Federal agencies, in the study of *Federal Support to Universities and Colleges and Selected Non-profit Institutions, Fiscal Year 1970,* reported in terms of obliga-

[1] It should be emphasized that analyses such as this one are projections and not predictions. These projections are derived from statistical models based on past trends and on an awareness of current happenings. Actual events may well turn out to be different from some of the projections.

tions. In terms of constant dollars, the effective increase in expenditures over the 2 years from 1968 to 1970 was substantially less–about 5 percent. During the same period, college enrollments rose by 13 percent. The net result of increased costs, enrollments, and changed funding was found to be a decline in the effective support of academic science of between 5 and 10 percent from 1968 to 1970.

Large universities and private institutions as separate classes were hardest hit, each reporting an increase of only 4 percent in total expenditures for the school year 1970, a rise which did not cover average increases in costs. Academic officials reported impairment of graduate programs and research, curtailment of facilities and equipment support, adverse career and employment prospects, administrative difficulties, and lowered morale of students and faculty. New and developing institutions frequently reported problems in meeting planned goals as a result of changes in Federal funding.

Economic Impact of Research and Development. The interest in the relationship of research and development to economic growth and productivity was a major influence in the Foundation's commissioning of four distinguished economists to prepare papers on the topic. A resulting "Colloquium on the Relationship between Research and Development and Economic Growth/Productivity" was held to review these papers and to discuss the subject in general, with some 70 representatives of Government, universities, and other institutions participating. The major conclusions reached were: (1) available evidence indicates that research and development is an important contributor to economic growth and productivity; (2) differences concerning present research findings seem to affect the degree of confidence in the estimates rather than the direction and rough magnitude of the economic return; and (3) the United States is probably underinvesting in civilian sector research and development from a purely economic growth/productivity point of view, though little can be said as to where particular R&D investments should be made. Publication of the papers and proceedings is planned for fiscal year 1972.

Science Policy Studies

Activities of COSPUP-COPEP

The Foundation has continued to provide support to the Committee on Science and Public Policy (COSPUP) of the National Academy of Sciences for guidance on priorities in scientific research. In December 1970, the Academy published *The Life Sciences* covering recent progress and application to human affairs, the world of biological research, and requirements for the future. Additional surveys of technical priorities in the disciplines of physics and in astronomy are well along. The most recent COSPUP survey, undertaken by the Academy with support from the Foundation and the Advanced Research Projects Agency (ARPA), concerns Materials Science and Engineering.

A parallel Committee on Public Engineering Policy (COPEP) of the National Academy of Engineering has continued to receive support. During fiscal year 1971, two COPEP reports were published, *Federal Support of Applied Research* and *Priorities in Applied Research,* which were integral to the planning and initiation of the Foundation's new program of Research Applied to National Needs (RANN).

Retrospective Analysis of Key Scientific Events

Also during fiscal year 1971, a follow-up to the 1969 report *Technology in Retrospect and Critical Events in Science* (TRACES) was initiated. The first TRACES study traced the key R&D events which led to five technological innovations with major economic and sociological impacts. The new study will build on the cases and materials developed in the original study and will expand the number of case histories with five new ones concentrating on innovations with major societal benefits. The study will concentrate on the principal interface between basic knowledge and application and will try to identify major factors which accelerated the application phase.

University Science Planning and Policy

The University Science Planning and Policy Program is designed to develop capabilities for research and teaching in the area of science planning and policy, and to support research on national science policy issues.

Institutions currently receiving grants under this program include: Harvard University, Massachusetts Institute of Technology, State University of New York at Albany, Cornell University, Rockefeller University, Stanford University, Indiana University, and the Universities of California (Berkeley), Illinois, Virginia, and Washington.

These grants help to support teaching, research, and special seminars on such science policy problems as the support and use of science and technology; the use of science in international affairs; scientific and technical manpower; environmental management; nuclear energy; the law and international affairs; the effects of new educational technology; legal and moral implications of modern biology and medicine; the effects of technology on economic growth and telecommunications policy.

Under current grants, Harvard University is developing a series of case studies to demonstrate the application of analytical techniques to public policy problems; Stanford

University is analyzing the technical and policy alternatives involved in cable television; the University of Washington is studying the problem of the Social Management of Technology; Rockefeller University is sponsoring a series of seminars on science policy problems; and Cornell University is studying and teaching such subjects as Biology and Society, Social Implications of Technology, and Technology Assessment.

PUBLIC UNDERSTANDING OF SCIENCE

The Public Understanding of Science Program, in conjunction with other science education and information programs of NSF, through support of projects by nongovernmental organizations, seeks to enhance citizen knowledge and understanding of both the potentials and the limitations in the use of science and technology. This involves not only communicating the "facts" of science but an understanding of the relationships of science to the universe we live in and the use of science and technology in meeting current and emerging societal problems. In fiscal year 1971, the Foundation made 11 awards amounting to $436,279 for public understanding of science projects. These included general support of public understanding of science activities; the design and production of films illustrating the nature and application of science, science exhibits in museums and public buildings; specialized seminars for science writers; and mobile science "laboratories" designed to demonstrate science in locations where people live and work. This year was a formative one for the program which is now administered by the Office of Government and Public Programs. New program guidelines were developed and issued to encourage the scientific community to become involved in and take responsibility for communicating the results and impact of scientific research to the general public.

In order to stimulate interest in science on the part of young people and to disseminate information on science to a broad audience, a general-support grant was made to Science Service, Inc. Other projects supported during fiscal year 1971 included an award to the Maryland Academy of Science for a public lecture series by scientists on the subject of science and its contribution to the quality of life. The Academy schedules engagements with civic and professional groups, chambers of commerce, PTA's, educational groups, and other public audiences throughout Maryland.

A public exhibits program on science was supported through the New York State Science and Technology Foundation. Unlike more traditional "fixed-base" science exhibits in museums, these large but portable exhibits are designed for use at a number of sites throughout the New York City metropolitan area, chosen because of their suitability for reaching an unusual cross section of the public. The subjects chosen for each exhibit are common aspects of everyday experience with two specific characteristics—the subjects are of concern to most individuals in their daily lives and have an underlying structural basis in science or technology.

Two projects were supported in conjunction with other Foundation program offices to bring exhibits on science to both rural schools and communities and to neighborhoods and large schools in the inner city. The first project supports the Oak Ridge Associated Universities in the development of a prototype traveling lecture-demonstration program. One-day visits to 40 selected high schools in Tennessee and Alabama are planned in the first phase of the program. The other project under the direction of the Federal City College in Washington, D.C., involves the use of a mobile science laboratory, manned by FCC faculty and students, to help instruct District of Columbia high school students and residents on the relevance of science to problems of an urban community.