Science Education Support

Since the start of its activities in science education, the Foundation has been concerned with the training of enough scientific and technical manpower of high quality to meet the nation's needs. Science and technology have become, however, such integral parts of our society that an understanding of their processes is now recognized as essential even for those who are not and do not expect to become professional scientists or technologists. Clearly, the improvement of the nation's scientific research potential, through the education of scientists, continues as a priority goal for the Foundation. But fiscal year 1970 has seen new emphasis on efforts to educate all citizens in both the uses and the limitations of science and technology, particularly as these bear on the analysis of societal problems, finding of alternative solutions, and rational decision making. Thus, the Foundation's science education programs are evolving toward meeting the two goals of educating the nation's scientists and technologists and improving the quality of education in the sciences for all students.

Science education is a cumulative process which begins at the first-grade level and may extend beyond the earned doctorate. Since each successive level rests upon earlier levels, one cannot hope to improve materially the quality of education in the sciences, let alone the production of highly trained professionals, by concentrating efforts at any one academic level. Even massive effort at the graduate level produces limited results in the absence of improved preparation of students prior to that point. On the other hand, efforts at the early levels of education are ineffectual unless momentum can be sustained thereafter. The education activities of the Foundation are designed at each major level to address those components of the system which exert the most leverage in terms of improving science education, but with varying emphasis. At the graduate level, a major portion of support funds is invested in professional training of future scientists; at the undergraduate level, in the improvement of instructional programs and institutional capability; and at the pre-college level, in

Table 5
Education in Science
Fiscal Year 1970

[Dollars in thousands]

	Number of proposals received	Dollar amount requested	Number of awards made	Funds obligated
Graduate Education in Science:				
Fellowships	10,914 [1]	$73,063	3,082 [1]	$15,877
Traineeships	279	100,126	368 [2]	27,269
Advanced science education program	166	8,476	92	2,393
Undergraduate Education in Science:				
College teacher program	474	13,833	394	4,161
Science curriculum improvement	1,795	36,517	685	9,806
College science improvement program	104	18,610	46	6,829
Undergraduate student program	836	9,300	432	3,817
Pre-College Education in Science:				
Institutes	1,472	60,500	1,049	36,936
Cooperative college school science program	325	14,075	136	4,654
Course content improvement	101	11,504	77	6,507
Student science training program	305	4,873	130	1,931

[1] Individuals involved.
[2] Includes 89 same-year supplementary amendments not included in proposal count.

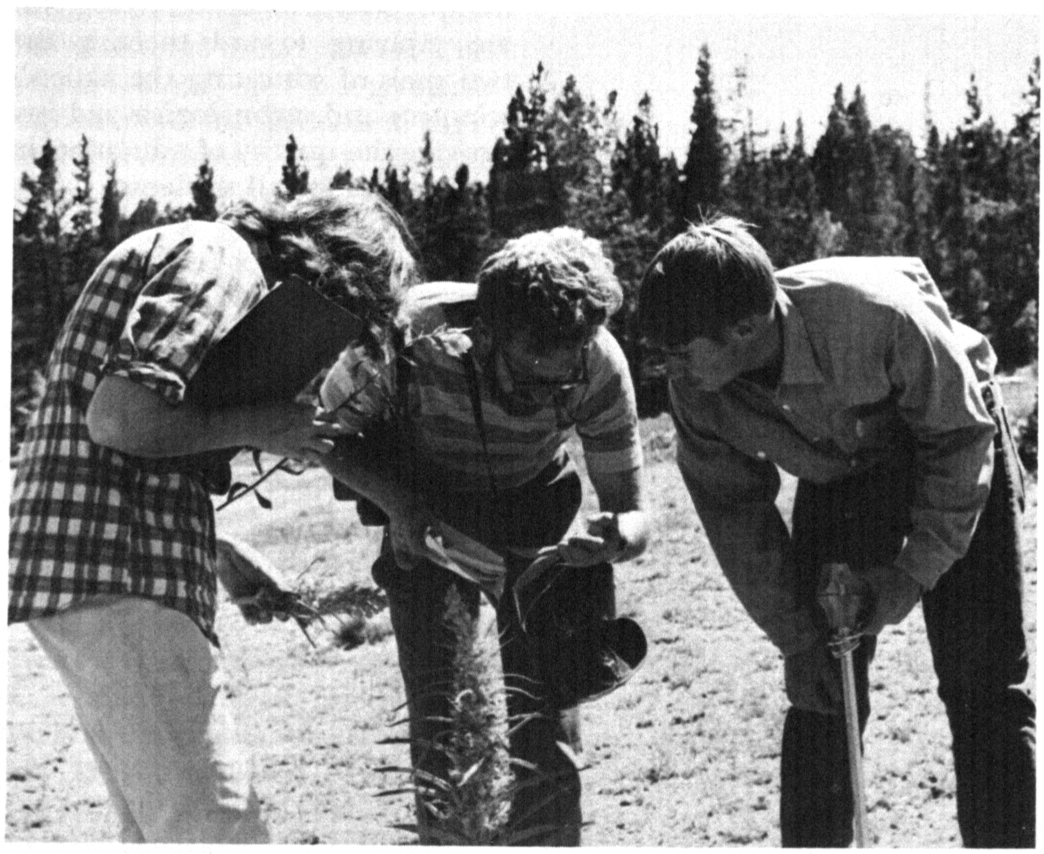
teacher training—but all these elements are represented at each level. Table 5 reflects NSF support for educational activities in fiscal year 1970.

The Quality of Science Education

Early Foundation efforts to improve the quality of science education in schools and colleges emphasized resources and personnel from outside the normal educational system or institution—particularly the improvement of teacher competency and the creation of high-quality instructional programs. Several years ago, it became clear, not unexpectedly, that the use of these external resources would be neither widespread nor—in many instances—effective without financial and professional assistance. Accordingly, some five years ago the Foundation began programs to help with actual implementation, e.g., the College Science Improvement Program at the undergraduate level and the Cooperative College-School Science Program at the pre-college level. Simultaneously, the existing teacher institute programs expanded their efforts to include increased participation by training specialists who could assist their schools in the adoption of new courses and methods. Looking ahead, the Foundation plans to support the generation and growth of capability *within* educational systems and institutions for locally initiated improvement of educational programs, relying on broadly constituted curriculum and advisory groups and some of the resources developed over the last decade.

Assessments and Priorities

While the Foundation's education programs have evolved over the past several years from a limited manpower goal to include a concern with improved science educa-



In a unique project combining several program elements, the Foundation in 1970 supported a research project which included superior high school and undergraduate students working with a college teacher of science to explore the ecology of lands above the timberline. (Photos NSF) tion for all, and from the development of external resources to increasing emphasis on implementation and development of capability for locally generated change, the past year was one of particularly intensive review. A number of factors sparked this evaluation and planning: the recurring need to examine the efficacy of established programs, changes in the demands for and supply of different types of scientific and technological manpower, fiscal retrenchment both at government and local institutional levels, and—overarching all—ever more insistent pressures for reform at all levels of education.

NSF staff and consultant review and planning for educational programs was augmented by a study commissioned by the National Science Board and conducted by the Advisory Committee for Science Education under the leadership of Dr. Joseph B. Platt (President, Harvey Mudd College) and Dr. Herbert S. Greenberg (University of Denver). The study report develops a theme for the next decade: "To educate scientists who will be at home in society and to educate a society that will be at home with science." Recommendations to achieve this aim include:

> Grants to support faculty and graduate students for research in science education equivalent to those for research in science;
>
> Experimentation and innovation in the application of technology to education to develop not only better hardware systems specially designed for educational needs but also an adequate range of high-quality materials suitable for exploration of television and computers as instructional tools; and
>
> Increasing support for science education outside the formal classroom such as museum activities, travel exhibits, films, and television programs.

The report also makes specific recommendations at each level of education. At the graduate level, support is urged for advanced practitioners degree programs; revitalization of the master's degree for those who will be engaged in the teaching and application of existing knowledge rather than creating new knowledge through research; and innovation in interdisciplinary course content. At the undergraduate level, the report recommends improvement of science courses for the non-science major; development for science majors of interdisciplinary problem-oriented science programs; increase and improvement of the science component in the education of prospective teachers; greater emphasis on two-year programs for the training of technical personnel; and some experiments in restructuring the total undergraduate experience. Recommendations for the pre-college level include second-generation course development focused on interdisciplinary, vertically integrated course sequences; production of outlines and suggestions to be adapted by teachers to fit local conditions; increased support for social and behavioral science curricula and teacher training; and support of experimental schools exploring major changes in the school environment.

New Directions

The Committee's recommendations and the staff planning have found expression in specific program activities during fiscal year 1970 designed to meet the current challenges in education. A number of projects supported in the Advanced Science Education Program are experimenting with alternatives to the traditional research Ph.D. programs. These experiments are given impetus by the changes both in manpower needs and in the interests of students oriented more and more toward interdisciplinary problem-solving rather than research in a narrow specialty. A newly established program at the undergraduate level — Student-Originated Studies — will support projects by creative and able students who wish to take a hand in their own education while gaining an understanding of how to analyze science components of a problem and formulate possible approaches toward solutions. An increasing number of projects are concerned with developing new instructional patterns for the undergraduate preparation of prospective technical and teaching professionals. At the pre-college level, fiscal year 1970 was marked by growing coordination between curriculum development and the training of teachers who can implement new curricula. Also, an increasing number of principals, science supervisors, and science education faculty from colleges and universities have received special information and training instruction so that a cadre of supervisory and resource personnel will be able to aid individual classroom teachers.

In addition to its investment in individuals to recognize and develop scientific talent, and in instructional programs and the training of instructional personnel to improve the quality of science education, the Foundation is also concerned with exploring and defining the role of educational technology (computers, television, film, programmed instruction) and with support of basic research that has educational significance. Projects in support of these two aims are funded through several of the education programs, often in conjunction with the Office of Computing Activities or the Division of Social Sciences. The following reports for each education division illustrate in greater detail the direction that the Foundation's science education activities are taking.

GRADUATE EDUCATION IN SCIENCE

The Foundation's concern with graduate education in science is apparent not only in its graduate education programs, but also in the emphasis given it in research and institutional programs. Support is extended to talented individuals for graduate and postdoctoral study through a variety of fellowship and traineeship programs. From 1952 through 1970, the Foundation will have funded about 65,000 awards for 9 or 12 months' study at the graduate level. Research grants to institutions of higher education usually carry a component of support for graduate students—some 6,000 being so supported in fiscal year 1970; special grant programs to support in-depth field work directly pertinent to dissertation projects contribute to the quality of the individual's training; large development grants to institutions—or to departments within institutions—are designed to improve their graduate education programs. Graduate students are also supported through the National Research Centers, the Sea Grant Program, and in various National Research Programs. Through these mechanisms, NSF provides support for nearly one-fourth of all science students holding federally funded awards.

In direct support of graduate education, fellowship programs designed as open national competitions for graduate students identify scientific talent and provide support to develop that talent to its fullest potential. Similar programs serve to further advanced training for postdoctoral and senior postdoctoral scientists and members of the science faculties of colleges. Particularly in the senior postdoctoral and science faculty programs, a major effect is on higher education itself, since fellows from those programs return with new training and insight to their teaching responsibilities. In addition to those programs, traineeship grants permit institutions to make their own selection of recipients for support of graduate studies and develop graduate departments. A program that brings outstanding foreign scientists in leadership roles to U.S. faculty positions for periods of up to one year adds new perspectives and experience to U.S. faculty members and graduate students, and strengthens scientific cooperation and understanding on an international basis. Table 6 shows the number of individuals supported with fiscal year 1970 funds under each of these programs.

Through the Advanced Science Education Program (ASEP), grants are made to institutions for the development of innovative graduate-level course offerings, to experiment with new kinds of educational techniques, and to examine the needs and problems in various disciplines so that graduate education in science can evolve to keep step with the changing needs of individuals and society as a whole. A particular responsibility of ASEP is the funding of Advanced Training Projects which provide educational opportunities for graduate and postdoctoral students and for graduate-level faculty where no training is available through regular university offerings.

Scientific Manpower and Graduate Education

The Selective Service Act had its most severe impact on the NSF Graduate Fellowship Program during 1969–70. Of the 2,500 persons offered fellowships for the year, a total of 101 requested that the awards be deferred because of military obligations. It appears that the Congressional action in December 1969, which made possible the order of call on a lottery basis, may result in a reduction of this impact, since the rate of deferment requests to date has been half that of last year.

Fiscal year 1970 was a period of intense re-examination of the whole manpower question as it relates to graduate education in science. In some areas of science, particularly physics and mathematics, it appeared that the number of Ph.D.'s produced during the last decade had satisfied or even surpassed demand for their services in the usual professions associated with academic careers or industrial research. Conflicting statements as to the seriousness of the situation have appeared, but the supply of traditional Ph.D. manpower seems to be coming into balance with the need. Recent studies have also shown that, since the mid-1960's, there has been a trend toward disinclination on the part of graduate students to enter the science fields, with a resulting decrease in enrollments. The decrease in Federal support for research and graduate study is likely to result in an even sharper decrease in the overall graduate school enrollment beginning in the fall of 1970. The Foundation is planning readjustments in its support of graduate students to take account of these projections and trends while still meeting anticipated needs for the 1970's. With less Federal support for graduate students, an increase in the number of part-time graduate students is anticipated; accordingly, the graduate traineeship program has been adjusted to permit institutions to award part-time traineeships beginning in the fall of 1970.

Another likely result of decreased Federal support is an increase in the number of students who will pursue the master's degree as a terminal degree. Some graduate training will probably be necessary for many scientific and technological professions immediately below the

Table 6
NSF Fellowship and Traineeship Programs
Fiscal Year 1970

	Awards requested by institutions	Individuals involved in applications	Fellowships awarded	Net amount
Graduate traineeships	17,510([1]224)		5,301([1] 224)	$26,240,000
Summer traineeships for graduate teaching assistants	8,737([1]211)		938(207)	1,029,290
Graduate fellowships		8,201	2,212	10,374,817
Postdoctoral fellowships		1,295	109	1,000,000
Senior postdoctoral fellowships		338	50	686,000
Science faculty fellowships		994	209	3,083,889
Senior foreign scientist fellowships		86	61	779,518
Total	26,247	10,914	8,880	43,146,514

[1] Number of institutions involved.

top levels, so that the master's rather than the doctorate degree may well become the target of a large segment of the student population. The Advanced Science Education Program is supporting several projects designed to explore the role of the master's degree. For instance, Georgia State University is developing a master's degree physics program to serve both part-time students from industry and students preparing to become secondary school and junior college teachers.

Improving the Quality of Graduate Education

An important resource to institutions trying to strengthen their graduate programs is the Senior Foreign Scientist Fellowship Program. It brings to institutions in this country foreign scientists whose training, experience, and formal accomplishments enable them to make significant contributions to the education and research programs of the host institutions. The increasing importance of this program for U.S. institutions is indicated by the extent of their participation this year, the greatest since inception of the program in fiscal year 1963: nearly 85 percent of the eligible institutions nominated candidates. The selection process is such that individuals nominated for the fellowships are able to exert in-depth influence within the departments they join, usually for a year, where they are considered members of the senior science faculty. They teach, lead faculty seminars, collaborate with and guide research activities of faculty and graduate students, contribute to professional society meetings in the United States, lecture at nearby institutions, and participate fully in the departmental development programs of the U.S. universities. They also bring to the institutions different views in their fields of science, particularly in smaller departments, and afford educational opportunity and scientific expertise often not available in this country to faculty personnel as well as to students. In addition to being an important resource in upgrading graduate science education in this country, the association between the outstanding foreign scientists and their colleagues in the United States adds a significant increment to the improvement in international understanding and cooperation.

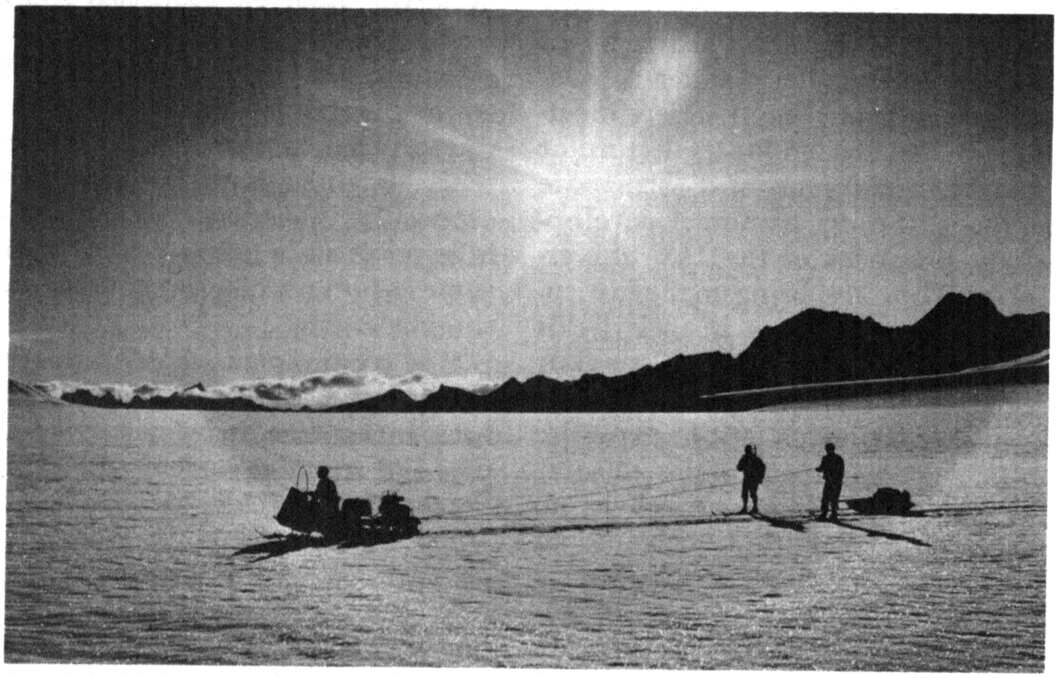
The Senior NATO Fellowships in Science Program (administered but not funded through the Foundation) also provides resources for strengthening graduate education by allowing a limited number of senior staff members of U.S. institutions to spend short terms (usually 1 to 3 months) in other NATO countries to learn new developments in their fields of specialization. In fiscal year 1970, 36 individuals received support for senior NATO fellowships.

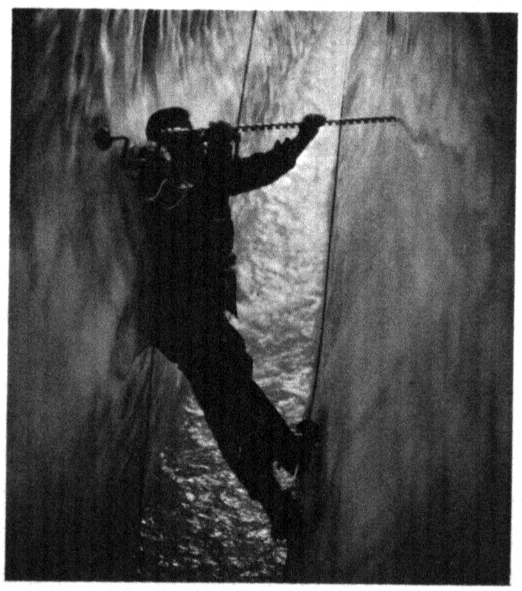
In attempting to improve and introduce new directions into graduate education, the Foundation is particularly concerned with the societal problems facing the nation in the next decade. Solutions of these problems will require broadly trained, creative individuals capable of working in interdisciplinary teams. In its fellowship programs at the postdoctoral level, the Foundation has invited applicants whose training and experience are in one field of science to propose plans of study or research in different but related fields. For instance, a person trained in chemistry might wish to tackle problems associated with air or water pollution and, to be effective, might need additional training in atmospheric or oceanic sciences. In another area, a person whose training is in business-cycle economics might now wish to undertake research in urban planning or some other sociological aspects of the inner city.

The training provided through Advanced Training Projects is frequently interdisciplinary in nature and aimed at current problems. Some of the fields of science in which courses, seminars, symposia, or field work were supported this year are: molecular techniques in developmental biology, geographical analysis of U.S. metropolitan areas, behavioral and social science in legal education, earthquake engineering, pest management, planetary atmospheres, and marine paleontology.

In addition to training scientists who can work in multidisciplinary areas, the Foundation is concerned with new interdisciplinary fields presently emerging as scientific disciplines. For example, a grant to the Greater Los Angeles Consortium, made up of liberal arts colleges in California, supported a conference in May 1970 on urban studies. Academicians from approx-

405-529 O—71——5





Under the program of Advanced Training Projects, the Foundation provides support for the Juneau Icefield Research Program, a long-term education and training project conducted by Michigan State University. In addition to academic courses in glaciology and related fields, graduate students receive practical training in the techniques of safe operation and survival in a variety of Arctic environments. (Photos Christopher G. Knight (c) National Geographic Society)

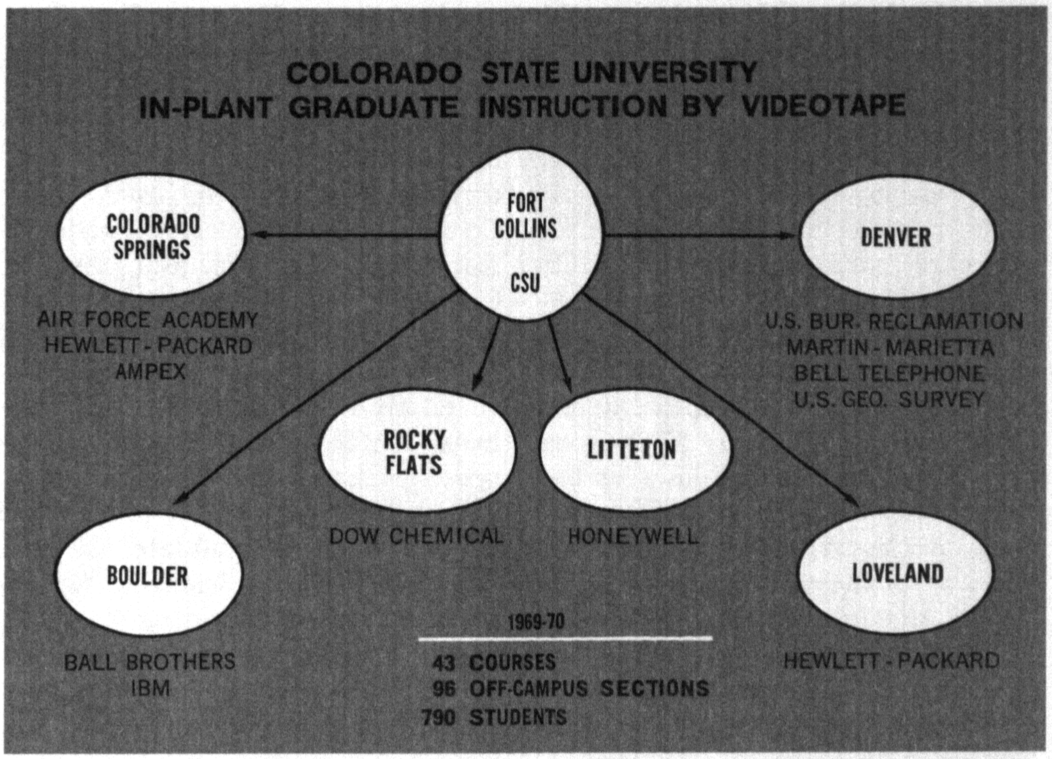
imately 25 colleges and universities in all regions of the United States who had been involved in urban and regional studies met with professional urban specialists for the purpose of evaluating the present state of urban studies as an area of science. Considered were such topics as: Should this be an undergraduate or graduate field of study? What preparation should its instructors receive? What kind of graduates does it seek to produce? Is interest in the field transitory, or will it become a distinctive discipline? A report of the conference is expected to have major impact in developing a degree-granting curriculum.

Alternatives in Graduate Education

A number of experimental projects supported through the Advanced Science Education Program are exploring new approaches to curricula or seeking alternatives to the traditional Ph.D. research degree so as to meet a variety of needs for highly educated science and technology professionals. An example of the kind of experimentation now underway is the recently established "SESAME" (Search for Excellence in Science and Mathematics Education) Ph.D. program at the University of California at Berkley. In this program, a student takes all the course work required for a Ph.D. in a specific discipline and a few courses in education. After passing a qualifying examination in his scientific field, the student undertakes a thesis research project dealing with educational improvement and innovation. The program seeks to encourage work in the area of science education by science faculty members and to train students who will be qualified to teach at the college level. In fiscal year 1970, the Foundation made a modest grant for this program to the university to help with facultyreleased time, educational research assistantships, and related expenses.

Several projects are trying to introduce greater relevance into graduate training for students who are both scientifically sophisticated and intensely concerned with societal problems. A student-initiated research project at Stanford University will permit graduate students to conduct a study of mass media coverage of environmental problems. The students will first construct an environmental picture of the San Francisco Bay area from available technical information and their own study of specific aspects of pollution. They will then analyze coverage of environmental problems in the newspapers, radio, and television. The two sets of information will be compared to determine the accuracy and scope of media coverage. The researchers plan to conclude the study with a seminar at Stanford University for editorial writers, environmental reporters, station managers, news directors, ecologists, and environmental specialists.

New graduate curricula in technology have received particular emphasis, especially those seeking to increase opportunities for continuing education on a part-time basis for employed individuals—generally industrial scientists and engineers. For instance, a grant to Creighton University will support a joint educational-industrial-governmental symposium to explore how universities can cooperate with industries and other organizations employing research scientists in a specific geographic area. A project at Colorado State University started out in 1967 developing videotapes for graduate instruction in several engineering areas to be taught at in-plant locations. Demand for the courses increased rapidly, so that by 1969–70, some 40 courses in a wide variety of fields were being made available to nearly 800 students at 14 off-campus locations. Moreover, the expanding clientele began to demand new graduate curriculum development. In the area of remote sensing of material resources, off-campus response was so great in 1969–70 that the enrollment exceeded the total interest in the subject at the university in all prior years combined. Hence, the university, with partial support through a 1970 grant, is now developing a major new graduate curriculum on the technology and application of remote sensing through new techniques using sound, light, radio, radar, heat, X-rays, and magnetism to monitor the environment.



UNDERGRADUATE EDUCATION IN SCIENCE

Foundation activity in support of undergraduate education in science must be sensitive to the critical nature of undergraduate education within the educational chain, as well as the diversity of the institutions in which it operates. In its position between the two other major educational "establishments"—pre-college education and graduate education—undergraduate education is the crucial connecting link between the generally uncommitted and the practitioner, for it is at the undergraduate level that serious preparation for a career begins. At the pre-college level the student may decide for or against "science;" at the college level he decides *which science*, if any, and in the 4-year college period must either acquire the knowledge and training that will enable him to pursue a career for which an undergraduate degree constitutes the necessary formal requirement, or build a foundation on which his specialized graduate training will rest.

Undergraduate colleges face a formidable task. They must take students from secondary schools with very good to very poor preparation, and they must recognize the wide variety of career choices possible and offer the necessary preparation. Further, they cannot overlook the fact that modern society requires that there be within the citizenry at least a core of educated nonscientists who understand science and its interactions with society.

The 2,550 undergraduate colleges are far more diverse in nature than either the secondary schools or the graduate schools: 12 percent are parts of major institutions offering graduate education to the Ph.D. level; another 21 percent offer graduate work through the master's degree; for 30 percent of them the baccalaureate is the highest degree granted; and another 37 percent offer something less than the baccalaureate, usually the first two years of undergraduate education. In each of these categories, institutions range in size from enrollments of less than 100 to thousands or tens of thousands. The quality of science education provided varies from totally inadequate to excellent.

Even the best of the undergraduate colleges and universities find it difficult to maintain their positions as high quality institutions—not only because of increasing enrollments and the rate at which new knowledge is being developed but also because of the changing demands imposed by increasing expectations. The orientation of many science students toward courses of study relevant to societal problems is likely to force major changes in science curricula. Advances in science and a rapidly changing technology demand curricula that will permit far greater flexibility in career choices. Scientists are also increasingly recognizing that they can no longer concentrate only on reproducing their own kind—that they must take a hand in giving the great body of students, many of them heading toward nonscience careers, an understanding of what science is, of its impact on society, and of its importance to the nation's future.

During fiscal year 1970, the Foundation assisted with the maintenance and improvement of the quality of undergraduate science education through several programs, some of them of long standing. Over 3,000 faculty members from 4-year and junior colleges participated in programs to enhance or update their knowledge and capabilities through Summer Institutes, Short Courses, or the Research Participation programs operated through College Teacher Programs. Support for the improvement of undergraduate science curriculum was provided through the Science Curriculum Improvement Program, supporting the development of teaching materials adaptable to use by a variety of undergraduate colleges; the Instructional Scientific Equipment Program, providing matching funds for the purchase of instructional equipment for use in science laboratories and demonstration lectures (suspended for fiscal year 1971); and the Pre-Service Teacher Education Program, assisting in the development and modernization of programs to produce adequately prepared teachers of science for the secondary and elementary schools.

The College Science Improvement Program is aimed at improving the overall instructional programs of institutions. Through its three sections, it provides (A) comprehensive support for the improvement of a wide range of instructional activities in individual colleges; (B) support for associations of 4-year colleges to carry on cooperative projects beyond the capabilities of an institution working independently; and (C) support for associations of junior colleges working with a major college or university on problems of curriculum and curriculum articulation. Table 7 records fiscal year 1970 funding of the respective components.

Through the Undergraduate Research Participation Program, over 3,100 students shared in the research and study activities of university scientists, thus gaining intensive exposure to both the satisfactions and frustrations that scientific work can bring. A small but significant number of special projects were funded to encourage development and testing of new ideas, concepts, and techniques in the teaching of undergraduate science.

In its programs to support undergraduate science education, the Foundation, while recognizing the need for maintaining and indeed improving the preparation of those who will be the nation's future scientists, has also turned its attention to new problems and ways to help undergraduate institutions meet their changing responsibilities. In this endeavor, several areas have begun to receive particular emphasis.

The Need for Relevance

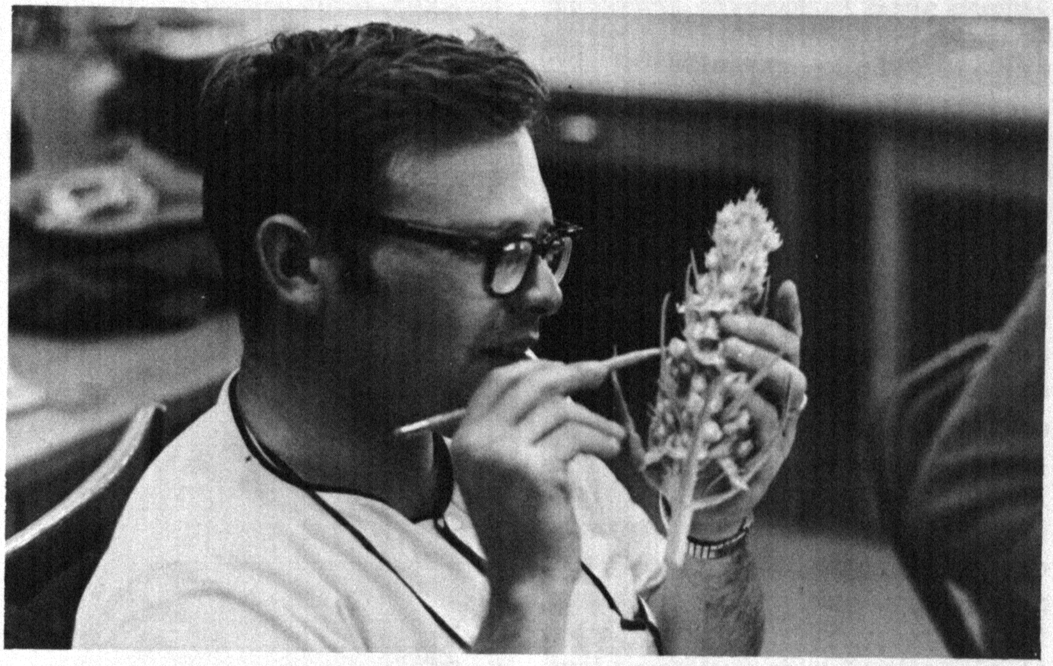
One of the major issues in undergraduate education is the need to face the question of what science has to offer in the solution of problems of intense concern to many undergraduate students, particu-

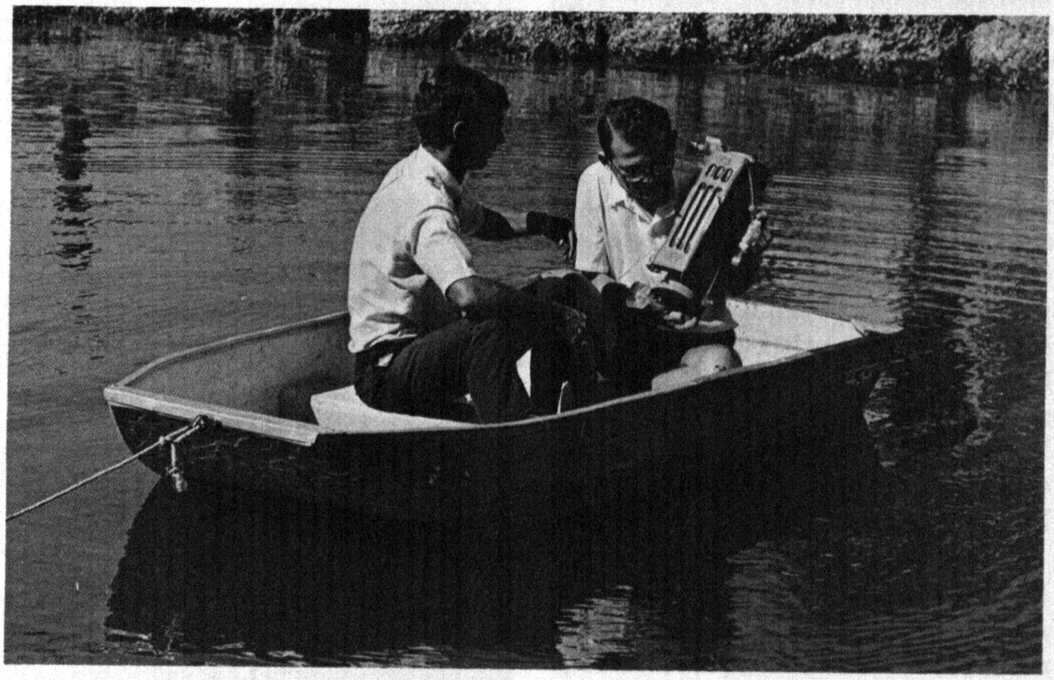
Table 7
College Science Improvement Program

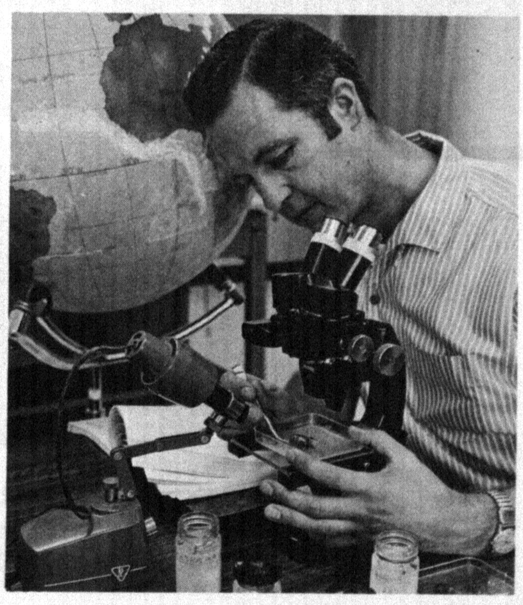
	Requests		Grants	
	Number	Amount	Number	Amount
Individual Institutions	58	$12,812,984	25	$5,235,900
College Associations	20	3,869,344	11	887,500
Junior College Cooperative Projects	26	1,927,400	10	680,800
Evaluation Contract				25,000
Total	104	18,609,728	46	6,829,200

larly the contamination and pollution of the physical, biological, and social environments. Several of the NSF undergraduate programs are encouraging the introduction into curricula of a consideration of the applications of science to a wide variety of these emerging problems.

An increasing number of college teacher programs will respond to the desire of undergraduate teachers for better understanding of the interactions of science and technology with society. For example, a Short Course on "Models of Urban Spatial Structure and Ecology" at Ohio State University is being given in response to the recent convergence of research themes in economics, geography, sociology, and social psychology which focus on the structure and organization of urban space. Problems of metropolitan government, transportation, land use, housing, employment, social conditions, and health all have important spatial dimensions which at present are only partially understood. It is the intent of the Short Course to review critically ongoing research into the spatial structure of cities and to promote the dissemination of urban research findings among a wider group of social scientists and policymakers. Another Short Course on "Engineering and the Technological Society" at Ohio University assists social science teachers in assessing the social consequences of technological development—such phenomena as machines, automation, energy resources, the computer—and encourages them to develop curricula on the role of technology in our society. A Summer Institute on "History of Technology" at the Smithsonian Institution surveys the evolution of technology from antiquity to the early 20th century, with emphasis on the interactions between technology and the physical sciences and on the unsolved problems. Discussion of these problems—requiring no costly equip-



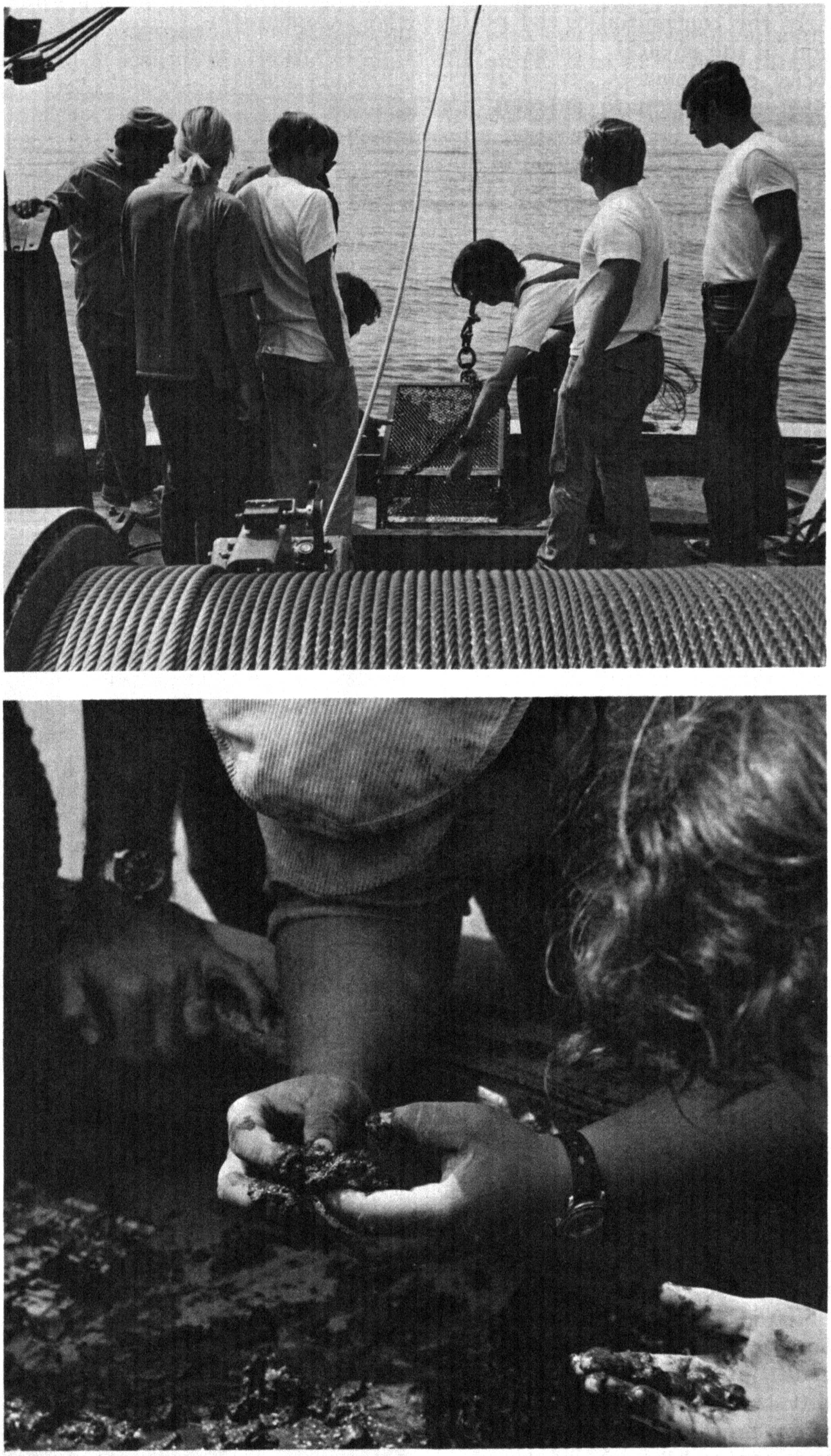




During fiscal year 1970 more than 3,000 college teachers participated in programs to enhance or update their knowledge and capabilities through Summer Institutes, Short Courses, or Research Participation. (Photos University of Miami) ment or personnel—is particularly well suited to exploitation by teachers at smaller colleges. The institute also includes opportunity for original investigations using the notable resources and personnel of the Smithsonian Institution.

At several institutions, support under the College Science Improvement Program has facilitated introduction of more "relevance" into courses and curricula. For example, the Departments of Physics and Biology at Albion College (Michigan) are concerned with revising curricula so that they recognize and attack significant current problems. Former science students and other visiting scientists, including at least one Nobelist, have served as advisors and lecturers while the college faculty are carrying out the curriculum changes. At Sweet Briar College (Virginia), the focal point of the project is the establishment of a center for ecological studies utilizing the college's exceptional campus of 3,400 acres and the surrounding rural and urban communities. Participating in this multidisciplinary activity are the Departments of Biology, Psychology, Economics, Government, Sociology, and, to a lesser extent, Chemistry and Physics.

Several proposals reaching the Undergraduate Special Projects Program indicate that, in faculty-student interactions, students are often the prime moving force. During fiscal year 1970, five grants were made to support student-originated and -managed research or study projects directed toward problems of the physical, biological, and/or social environment. For example, at Heidelberg College, five undergraduate students will conduct a study of pollution of the Sandusky River. The students plan to investigate the extent of agricultural fertilizer runoff and its contribution to the nutrient pollution of the river, the rate at which biodegradable detergents in the river break down as the water



Undergraduate students from several Southern California colleges collect marine samples from the teaching-research vessel *Vantuna,* developed with the aid of a College Science Improvement Program grant. (Photos Occidental College) temperature changes, and oxygen depletion below the towns of Bucyrus and Upper Sandusky. Through the project, the students hope to obtain results useful in local pollution controls, but with applications to more widespread problems; and to arouse interest and gain experience in environmental research. In recognition of the strong student interest in such problems, and to encourage students to express productively their concern for the environment, the Foundation announced (on Earth Day, April 22, 1970) its intention to initiate a new program, Student-Originated Studies (SOS), to provide support for interdisciplinary groups of college and university students prepared to undertake a search for solutions. It is expected that the first grants under SOS will be made in fiscal year 1971, with project activities beginning in the summer of 1971.

The Junior Colleges and Technician Education

Since 1965, when NSF institutes and short courses for college teachers were opened to applications from junior college teachers, the number of participants from junior colleges has risen steadily. In the spring of 1968, at a combined meeting of project directors of all college teacher programs, a full session was devoted to a discussion of the college-parallel programs offered in junior colleges, the project directors being joined by a large number of junior college representatives. That meeting culminated in suggestions for an entirely new cooperative program for junior colleges, directed toward developing better articulation between the programs of the 2-year colleges and the upper-level programs of 4-year colleges and universities. The proposed program, now identified as one component of the College Science Improvement Program, was initiated in the following year and has, since its beginning, provided funds amounting to $2.7 million for support of 41 associations of junior colleges (a total of 467 colleges) in 23 States, each association working in cooperation with a major nearby college or university.

The Foundation recognized, even then, that in concentrating its attention on college-parallel science courses, it was essentially ignoring one of the important fields of activity of many of the junior colleges—that of providing training for students in technical fields. The extent to which the Foundation should become involved in the education of technicians and technologists was at one time a question of major concern. The question as to "whether" was resolved in 1969 with the decision to support several institutes dealing with technician-training subjects. Fiscal year 1970 saw expanding support for technical education, most of it directed toward development of curricula and teaching materials for training of the kinds of technicians now needed to provide adequate backup for scientists and engineers. For example, the Chemical Technician Curriculum Project (ChemTec) has begun development of curriculum materials for a 28- to 30-semester-hour chemistry core for a 2-year college level program in chemical technology. Located at the Lawrence Hall of Science in Berkeley, Calif., the project developed in summer 1970 texts, laboratory experiments, film-loops, and other teaching materials, which are being field tested in 12 pilot schools during academic year 1970–71. The experience accumulated will be used to revise the materials in the summer of 1971 and prepare them for release through conventional commercial channels. So that the training will be consistent with the abilities and interests of the target group of students, the curriculum will emphasize laboratory work and direct "hands-on" experience. The aim is comprehensive coverage of basic chemical subject matter which, through modular organization of the content units, will encourage the inclusion of locally important topics and modifications.

A major study of engineering technology education is being conducted by the American Society for Engineering Education as a guide to later developments and to institutions engaged in the training of technicians and technologists. Included is a broad survey of all technology education — 2-year, 4-year, and graduate programs—together with an assessment of the industrial demand for the personnel output at the various levels of training, and suggested curriculum accreditation standards.

Based on experience with projects thus far supported, and in response to a number of recent studies indicating a continuing shortage of adequately trained technicians and technologists, plans have been developed for introduction, in fiscal year 1971, of a new program specifically oriented toward Technical Education Development.

Pre-Service Teacher Education

The Pre-Service Teacher Education Program has, up to fiscal year 1970, been concerned with the education of prospective elementary and secondary school teachers. During the past year, however, concern about the preparation of teachers at the college level increased considerably—not about their knowledge of the subject matter of science, but about their acquaintance with the teaching-learning process. There is questioning, too, of the preparation for teaching offered in the course of earning the Ph.D., even though many who take this course will eventually become teachers in undergraduate colleges. Fellows and research assistants may have little chance to learn about the rewards of a career as a teacher;

teaching assistants often have a distressing or disappointing experience, as too many are expected to function without benefit of guidance, to the detriment of their undergraduate students. Several conferences held during the year have addressed the problems in current patterns of using teaching assistants. Consideration is being given to providing support in some form that, while meeting the needs of the graduate students acting as assistants, will focus on providing better instruction for the undergraduates.

Problems of Communication with the Academic Community

Because adequate communication between the National Science Foundation and the college and university community is an integral part of developing effective support programs for undergraduate science education, strong efforts have been undertaken to further exchange of information. Mass mailings of lists of projects conducted under the Undergraduate Research Participation Program and the various Programs for College Teachers seem to be effective in apprising prospective participants of available opportunities, judged by the number of applications for participation. On the other hand, preliminary proposals for special projects and curriculum improvement indicate that the academic community is not sufficiently informed about projects and developments already under way. It is in this area—the dissemination of information about ongoing activities or about materials already developed and in many cases available for distribution—that avenues of communication seem ineffective.

Attempts were made during fiscal year 1970 to broaden these avenues in two ways. In February 1970, abandoning the project directors' meetings usually conducted program by program, arrangements were made for a more comprehensive meeting, bringing together for the first time project directors of all NSF undergraduate programs. This group, almost 1,000 in number, spent 3 days in Washington hearing about and discussing topics of current importance in undergraduate science education. Some of the topics covered were: instructional technology, new course patterns, science for nonscience students, student-originated research, graduate teaching assistants, preservice teacher education, and technology education.

The other attempt took NSF staff members out of Washington, closer to the scene of activity in the colleges and universities. For periods of 2 weeks, NSF staff were present in each of three major cities—Atlanta, Boston, and Minneapolis. Colleges in each of the areas were notified well in advance, and appointments were scheduled enabling individual faculty members or, more often, groups of faculty members, from area schools to discuss Foundation-related matters with NSF staff members on duty during the period. The response was greater than expected; during each 2-week period the staff were visited by, on the average, some 200 faculty members representing 40 colleges. Plans are now being developed to extend the operation to seven other areas during academic year 1970–71.

PRE-COLLEGE EDUCATION IN SCIENCE

Through the Division of Pre-College Education in Science, the Foundation administers programs for the development of scientific talent, the supplementary training of teachers, and the improvement of school science programs for all students. By far the largest portion of funds available for this level, nearly 75 percent in fiscal year 1970, is devoted to in-service training for secondary school teachers and supervisors through the various institute programs. These programs cover all the scientific disciplines and include a broad range of activities from short briefing conferences on new teaching materials to intensive studies during the academic year and/or adjacent summers. Nearly 50,000 individual teachers and science supervisors will participate in institute programs during the summers and academic year of 1970–71.

In addition, about 6,300 elementary and secondary school teachers will receive in-service training through Cooperative College-School Science (CCSS) projects. The primary objective of CCSS is the effective introduction of new teaching materials and methods in a school system or related group of schools through a plan developed jointly with a university whose staff then helps with implementation.

Course Content Improvement projects are concerned with developing better instructional materials for science education from kindergarten through the 12th grade, ranging from single-topic pamphlets to multimedia courses, from equipment for students to resource materials for teachers. Included also are Resource Personnel Workshops to train leaders who will then initiate local in-service programs for the effective use of new curriculum materials.

The Student Science Training Program for developing scientific talent is a relatively small component of pre-college activities, accounting in fiscal year 1970 for 3.7 percent of the total budget to support training for some 5,500 students. These special study opportunities in science and mathematics for high school juniors of outstanding ability not only further their science interests, but help them in career decisions which usually begin to crystallize at this level.

The way in which the various pre-college programs interact is il-

Students investigate gravitational potential energy in Physical Science II class. This course is intended for the middle segment of the high school population but can serve as a preparation for more specialized courses in science. (Photo Educational Development Center)

lustrated by several examples of the kind of approach made to problem areas that represent priorities for fiscal year 1970 and the coming years.

Second Generation Curriculum Efforts

During the past decade, Foundation support has been predominantly focused on strengthening the quality of instruction in the schools as they now function. The new courses developed and the programs for teacher training have emphasized up-to-date content and student experimentation and inquiry, but they were designed to fit established curriculum guidelines. The disciplinary structure of subject matter characteristic of the senior high school was maintained, with the middle school (7th through 9th grades) representing a transition stage to the basic disciplines of chemistry, biology, and physics. Mathematics is unique in the sciences in having a separate disciplinary niche throughout all levels of instruction.

With Foundation support, curriculum materials have been developed in mathematics and the natural sciences which can now be sequenced to provide a variety of curricula from kindergarten through high school, and a substantial start has been made in assisting schools in their implementation. The present stage of development can be regarded as a first generation effort. Two basic problems must now be confronted:

—Should there be a next round of curriculum effort, and, if so, what should be its directions?

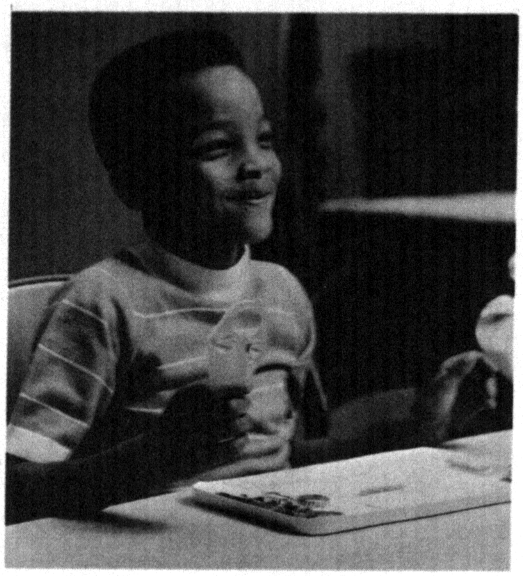
—How can the Foundation help improve the learning environment in the schoolroom? This includes not only problems of teaching competence and implementation of better curricula but also support of new ways to better utilize time and space.

In the consideration of these problems, new objectives have been identified and activities initiated or planned.

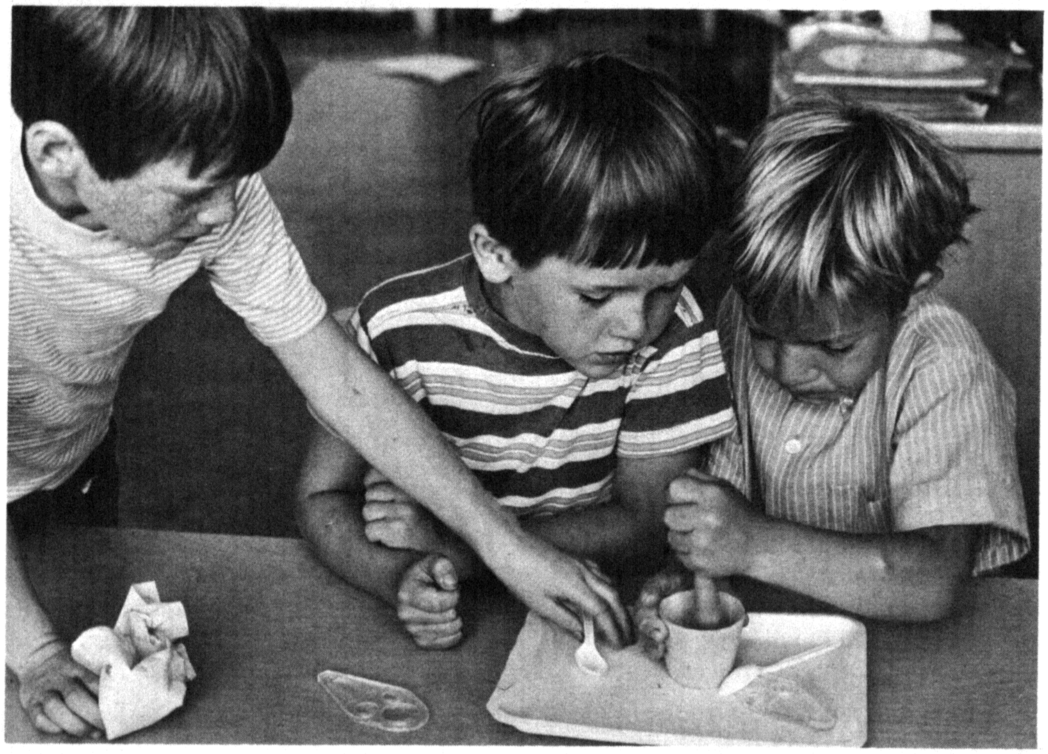
Scientific Literacy vs. Scientific Manpower

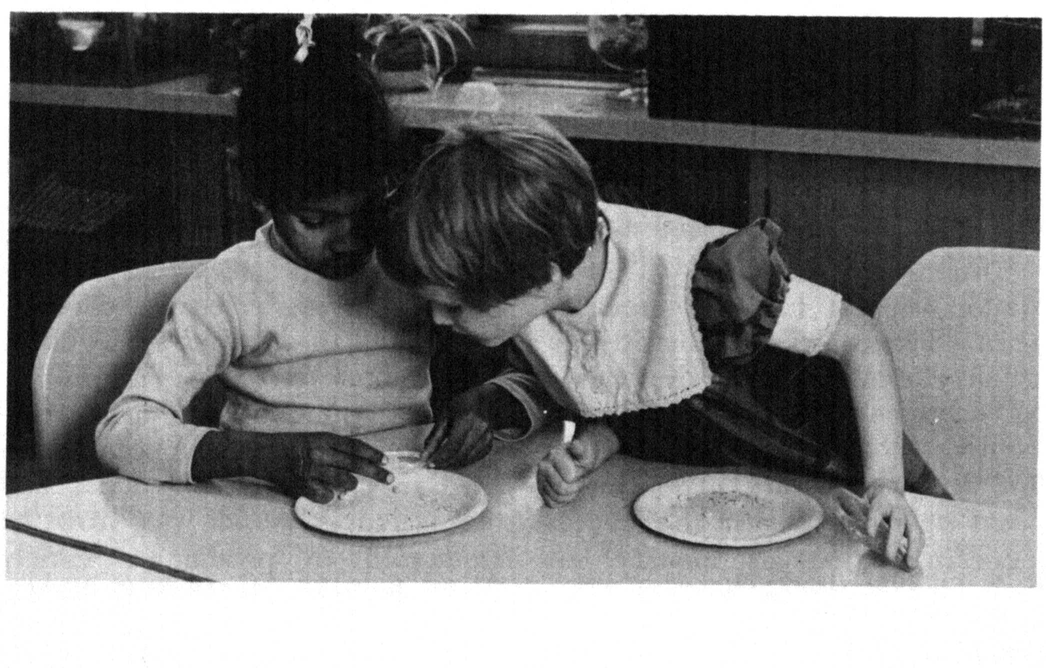
The first efforts supported in curriculum development in the early sixties were aimed at developing materials for the students who generally enroll in high school science courses, ranging from 80 percent in biology to 25 percent in physics. Some critics argue that these courses are too rigorous and sophisticated for nonscience students. For the junior high school and earlier, where all students take science courses, the materials have been specifically designed to fit the requirements of all students insofar as that can be done. It is now clear that a second generation of materials is required which provides more options and is geared to the needs of students not necessarily intending a scientific career. At the same time, efforts will continue to support development of some materials for scientifically gifted students when such needs are documented. For example, in fiscal year 1970 a grant was awarded to Columbia

University for an integrated mathematics sequence in grades 10–12. This is deliberately designed to serve high-ability students who are likely to become mathematicians. Over the last several years, however, support of materials for talented students has amounted to less than 10 percent of total pre-college course improvement, a proportion likely to be maintained for the present.



The Science Curriculum Improvement Study is developing ungraded, sequential physical and life science programs for the elementary school—programs which in essence turn the classroom into a laboratory. A child's elementary school years are a period of transition as he continues the exploration of the world he began in infancy. Extensive laboratory experiences at this time will enable him to relate scientific concept to the real world in a meaningful way. (Photos University of California, Berkeley)





Interdisciplinary Courses

A substantial investment has been made in the development of interdisciplinary courses for the junior high school level. An example of one of these will illustrate how curriculum development proceeds, and what subsequent steps are necessary to implement the new courses.

The Earth Science Curriculum Project (ESCP) was initiated in the summer of 1964 through a grant to the American Geological Institute. At that time, spurred by the nation's space exploration program and by increasing concern with the physical environment, rapid growth in earth science instruction took place in junior high school, but it was severely hampered by a dearth of good instructional material. Hence, earth scientists and educators planned, developed, and tested curriculum materials for a modern, interdisciplinary course. The textbook, *Investigating the Earth,* published in 1967 by Houghton Mifflin, is intended for use in the 8th or 9th grade, and covers the disciplines of astronomy, meteorology, oceanography, geophysics, geology and geography. The materials also include a laboratory manual, teacher's guide, field study guides, laboratory equipment and experiments. Current concerns of the study group are teacher training, both in-service and pre-service, implementation, and evaluation related to the use of the materials.

Assistance to schools in the effective use of the materials has been provided through teacher training institutes, cooperative college-school science projects, and resource personnel workshops which provide training for teachers who then become leaders for in-service training projects in their own areas.

An illustration of the implementation of ESCP materials is exemplified in the State of Missouri. A resource personnel workshop held at the University of Maryland in the summer of 1968 trained teams from all sections of the country in the use of ESCP materials. The teams consisted of a college or university scientist, a school administrator, and a classroom teacher-leader. The team from Missouri organized a "second generation" leadership conference supported by the Foundation in the summer of 1969 which was designed to prepare teams from eight Missouri colleges and universities for a State-wide in-service ESCP training program. This was followed by an In-Service Institute project, starting with a 1-week preliminary session involving the participants from the eight separate in-service institutes scheduled to begin locally in September 1969. The result of these activities is described by John Hooser, Missouri State Science Supervisor and a member of the initial Missouri team.

> "Prior to the earth science project, only a few schools offered earth science. The State Department of Education did not offer certification in earth science. Since this project, there are 126 school districts, 231 teachers, 761 sections, and 21,000 students involved in earth science in Missouri. The State Department of Education has certified requirements for earth science. The first year of funding has made it possible to involve 110 to 115 teachers with eight colleges in this State-wide earth science project. This is approximately half of the teachers presently teaching earth science in the State. The teachers enrolled in this program will fulfill about half of the required hours of certification."

Grants have been awarded in fiscal year 1970 for the continuation of the in-service program in the eight colleges. Grants for ESCP teacher training and implementation activities awarded in fiscal year 1970 throughout the country include 18 summer institutes and conferences, 54 in-service institutes, and 11 cooperative college-school science projects. These projects will provide a variety of training opportunities in the use of ESCP materials for over 2,000 junior high school teachers. It is estimated that over a third of the million students now taking earth science in the secondary schools of the country are using ESCP materials.

Finally, to round out the set of activities ultimately required for curriculum and teaching reform, the ESCP has this year received an NSF grant through the Division of Undergraduate Education in Science for a teacher education project in which the ESCP will assist and coordinate a consortium of colleges across the country in the establishment of undergraduate curricula for prospective earth science teachers geared to current materials and techniques. Included as participants in the project will be Boston College, Southern Illinois University, Minot (North Dakota) State College, California State College at Fullerton, the State University of New York College at Oswego, Western Connecticut State College, and Colorado State College.

Social Sciences Curriculum Materials

The social sciences represent a major curriculum area in which development of suitable materials has lagged rather far behind that for mathematics and the natural sciences, with large gaps over the whole kindergarten to 12th grade range. Because there is no discernible consensus as to what an integrated sequence might be, the Foundation has supported the development of specific high school courses in geography and sociology, and of supplementary materials in sociology and anthropology for use in social studies courses. An interdisciplinary effort was initiated this year, led by Dr. Irvin De Vore of Harvard, to create a behavioral science course for the intermediate level on the general theme, ***Exploring Human Nature.***

At the elementary level, an innovative 5th grade course neared completion in fiscal year 1970. This course, ***Man—A Course of Study,*** is based on three questions framed by Jerome S. Bruner, the principal developer: "What is human about human beings? How did they get that way? How can they be made more so?" The first half of the course concentrates on the life cycles and behaviors of salmon, herring gulls, and baboons. These studies lead students to assess the significance of generational overlap and parental care, innate and learned behavior, group structure and communication, and their relevance to the varying life styles of animal species, including the human species. The second half of the course is an intensive study of man in society—as culture-building, ethical creatures, toolmakers and dreamers. The Netsilik Eskimos of the Canadian Artic are studied in depth, because their society is small and technologically simple, yet universal in the problems it faces. Course materials rely heavily on research sources and present subject matter through a variety of media, including films, filmstrips, records, posters, and booklets.

This project posed an unusual distribution problem. Although the teachers and children involved in the trial phase of the development were enthusiastic about the course, commercial book publishers and film distributors were unwilling to contract for publication because of the variety of materials to be handled and the unconventional subject matter. Support therefore was made available to the sponsor, on the basis of a revolving fund award, to conduct a quasi-commercial publication and distribution operation to demonstrate the general public acceptance and the commercial feasibility of distributing the materials. The success of this venture is attested to by the fact that a publication contract has recently been executed with Curriculum Development Associates. Further implementation is being aided through the development of resource teams in teacher training institutions and through cooperative college-school science projects.

Teacher Participation in Course Development

One criticism of curriculum materials developed by nationally constituted groups of scientists and educators, and distributed through commercial channels, is that this procedure deprives local teachers of the opportunity to contribute their own creative efforts and develop their own ideas. As one approach to the problem, a grant was made this year to Indiana University for a project directed by Robert A. Hanvey to develop materials for supplementary units in cultural anthropology for secondary school social studies courses. These units will treat the topics of *Biological and Social Differentiation of Man* and *Science, Technology and Change,* each occupying from two to four weeks of class time. The final materials, instead of commercial textbooks, will be "unfinished" outlines, syllabi, and resource materials that may be fleshed out and refined to suit the teacher's specific needs and taste. Opportunities can then be provided through institutes or other means for individual teachers to complete adaptations for their own classes. To serve this kind of approach, the Summer Institute Program is encouraging prospective directors to submit proposals for special institutes in all disciplines that will permit teachers, with leadership from university scholars, to develop their own curriculum ideas which they do not have the time or resources to pursue during the teaching year.

Supervisory and Resource Personnel

There are two major problems in the introduction of new courses and methods into school curricula. One of these is the dissemination of information to administrators and supervisors sufficient to enable them to reach decisions on curriculum adoption. To try to meet this problem, the Foundation has begun support of short courses for administrators and science supervisors to acquaint them with new materials that are available. During the summer of 1970 the Foundation is supporting nine conferences for secondary school principals designed to provide information on curriculum developments. Also, the Association of Secondary School Principals cooperated this year in arranging informational workshops which were conducted during the annual meeting of the association. In addition, conferences for State science supervisors and State mathematics supervisors have been supported for the past 3 years. These conferences are concerned with current science education activities and problems; for example, this year's theme of the science conference was environmental education in the secondary school curriculum.

A second aspect of the implementation problem is the training of supervisors, subject-matter specialists, and resource personnel in the content and methods of new courses so that they can serve effectively as leaders in teacher training and implementation. Two avenues of support have been provided through pre-college programs. One of these is the Academic Year Institutes Program. Last year, the first academic year institute designed expressly for experienced, practicing supervisors was held at the University of Maryland, under the leadership of David Lockard. The applicant response to this innovation was so encouraging that a second such project is to be conducted by Ohio State University this year. Other academic year institutes stress intern training for science and mathematics supervisors-to-be, the placement of project graduates, and rigorous discipline orientation for subject-matter specialists in specific areas needing this kind of expertise.

The Resource Personnel Workshops approach the same problem in a different way by developing leaders in colleges and schools with sufficient in-depth understanding of one or more new curricula to initiate teacher training activities in their own schools and colleges reflecting the content and spirit of the new materials. This program, initiated as an experiment in 1967 with six grants, has expanded this year to 27 projects at a cost of over $1 million with provision for approximately 1,800 participants. The need for leadership training has been particularly acute at the elementary level since there is no existing cadre of experts for the interdisciplinary courses at this level analogous to college physicists, chemists, or biologists in the case of new high school courses in those disciplines. Demand for the elementary school materials is increasing as they become widely available, but familiarity with them has tended to be restricted to those science educators and teachers who had participated in their development.

Hence, the workshops are filling a real void in developing the resources necessary for implementing improved curricula.

One example of the "multiplier effect" of the workshop projects has been cited earlier in the Missouri implementation of ESCP materials. Another instance is the leadership development project in *Science—A Process Approach,* the American Association for the Advancement of Science elementary science curriculum, at Pennsylvania State University. The initial grant was made in 1968; follow-up studies in May 1969 (85 percent of those trained responded) revealed that the participants had trained 2,050 teachers, who in turn instructed almost 56,000 children in 1969–70. Moreover, those participants who are members of college faculties have already incorporated about 200 hours of instruction from the in-service course into their pre-service course for approximately 550 college students preparing to teach.

Experimental School Activities

To help each student learn at his own pace and to the extent of his own abilities, schools need to modify their rigid concepts of how to organize time and facilities, particularly at the elementary level. This is a difficult problem area for the Foundation which has historically been concerned with the support of science and mathematics education activities only. And yet, the problem is so critical and its scope so broad that joint funding with other agencies deserves consideration to support integrated educational efforts, with the Foundation responsible for the science and mathematics components. In this connection, Max Beberman at the University of Illinois received support this year for an intensive study of the suitability for U.S. elementary schools of the English "Integrated Day" approach. The main objective of the project is to establish at an experimental public school a working model of a total educational program which takes into account individual differences through using broad themes as vehicles for integrating the various traditional school subjects. The children work on projects, both individually and in groups. Emphasis is to be placed on interrelations between mathematics and science, the use of laboratory equipment and experimentation, and the invention of teaching procedures and student practices which develop the ability to reason.

Experiments of this kind appear to have great educational effectiveness in England, and offer promise for U.S. schools. It is therefore of prime importance to investigate the exportability of this kind of school experience to the American scene. The Foundation expects to extend this type of support to other experiments for reorganizing the structure of educational processes.

Program Evaluation

With rapid changes in the current climate of education, the present time is a critical one for reconsideration of NSF programs in precollege education. The educational structure and its modes of operation for which the established NSF educational programs were conceived seem to be undergoing irresistible pressures for reform. Earlier evaluations are now for the most part obsolete and often inadequate to provide guidance for planning purposes. Hence, the Foundation intends to place increased emphasis on evaluation. Initial steps were taken in fiscal year 1970 to evaluate the impact of the Academic Year Institutes Program with distribution of a questionnaire to all participants in this program since its inception in 1956. From the returns, the staff will derive information on how influential this program has been in effecting changes in secondary schools to date, and whether the investment in time and money for the teacher participants has paid off and will be likely to pay off in the near future.

Data are also being collected from a sample population of science and social science teachers. This study, undertaken by contract with Vitro Corporation, will establish a baseline of teacher characteristics of the present era, so that past and future comparisons will be possible. Student participants in the pre-college programs are also being followed up in a contract with the American Council on Education. Of particular interest is a comparison of the influence of the Student Science Training Program on the current generation of high school and college students as compared with those of a decade ago, since comparable data were collected in 1960.

Beyond the appraisal of the effects of individual programs, the Foundation is now exploring ways of studying the total impact of precollege programs through observation and data collection of change in science education in individual classrooms and school systems.

PUBLIC UNDERSTANDING OF SCIENCE

The overall objective of this program is public education with respect to science and technology, so that citizens may function more effectively in a technological society. This involves communicating not only the "facts" of science but also some appreciation of the relationship of science to other forms of scholarly investigation and some understanding of the scientific and technological aspects of societal problems. In fiscal year 1970 the Foundation made 15 awards, amounting to $212,488, for public understanding of science projects. The mechanisms employed included conferences, summer courses, an exhibit, design of a film series, curriculum development for an adult education program, and a State-wide information program on the scientific aspects of environmental pollution.

A recent issue of *Impact of Science on Society* discusses the problems of bringing about a public understanding of science. In one article Miguel Angel Asturias, 1967 winner of the Nobel prize for Literature, states: "In our day science and literature seem so far removed, so widely separated from one another that a poet or writer like myself looks with timid respect on everything relating to science, scarcely daring to inquire into, to glance at, the awesome discoveries of the scientists. There are those who speak, not unjustifiably, of a veritable schism in what is called Western culture, a schism which, at its most extreme, leads not a few men of letters and artists to ignore and despise the scientists and the technicians . . . ."

The problem is enormous and is compounded of a lack of knowledge of the humanistic origins of science, a confusion between science and technology, and a concern with the misuse of technology. What is worse—a misunderstanding of science and technology (and the difference between the two) is shared by the uneducated at all ages, by educated adults, and by many of our brightest youth.

The support of two seminars on the Impact of Science and Technology on Society for women community leaders and undergraduate women students represents an approach to the less scientifically oriented of our two sexes. These are to be carried out (one in September 1970 and one in January 1971) by the Oak Ridge Associated Universities, which in the past conducted similar programs for humanities professors and practicing clergymen.

Joint support of a Dialogue on the Identity and Dignity of Man with the National Endowment for the Humanities was an attempt to focus scientific knowledge and humanistic wisdom on such problems as Control of Population and Regulation of Behavior, Extension of Life Through Organ Replacement, and the Improvement of Life Through Genetic Manipulation. The dialogue was conducted at Boston University in conjunction with the annual meeting of the American Association for the Advancement of Science.

A Summer Session on the Quality of Life, supported by a grant to the Institute on Man and Science, helped a group of scientists, educators, doctors, lawyers, publishers, politicians, clergy, housewives, and students to explore the interactions of science, technology, and human values as they converge on environmental concerns. Predictions concerning the environmental state of the world in the near future were examined from the standpoint of solid experimental evidence, and participants sought solutions to real case problems such as the decision on where, if anywhere, in a given State to build nuclear reactors for increased electrical power.