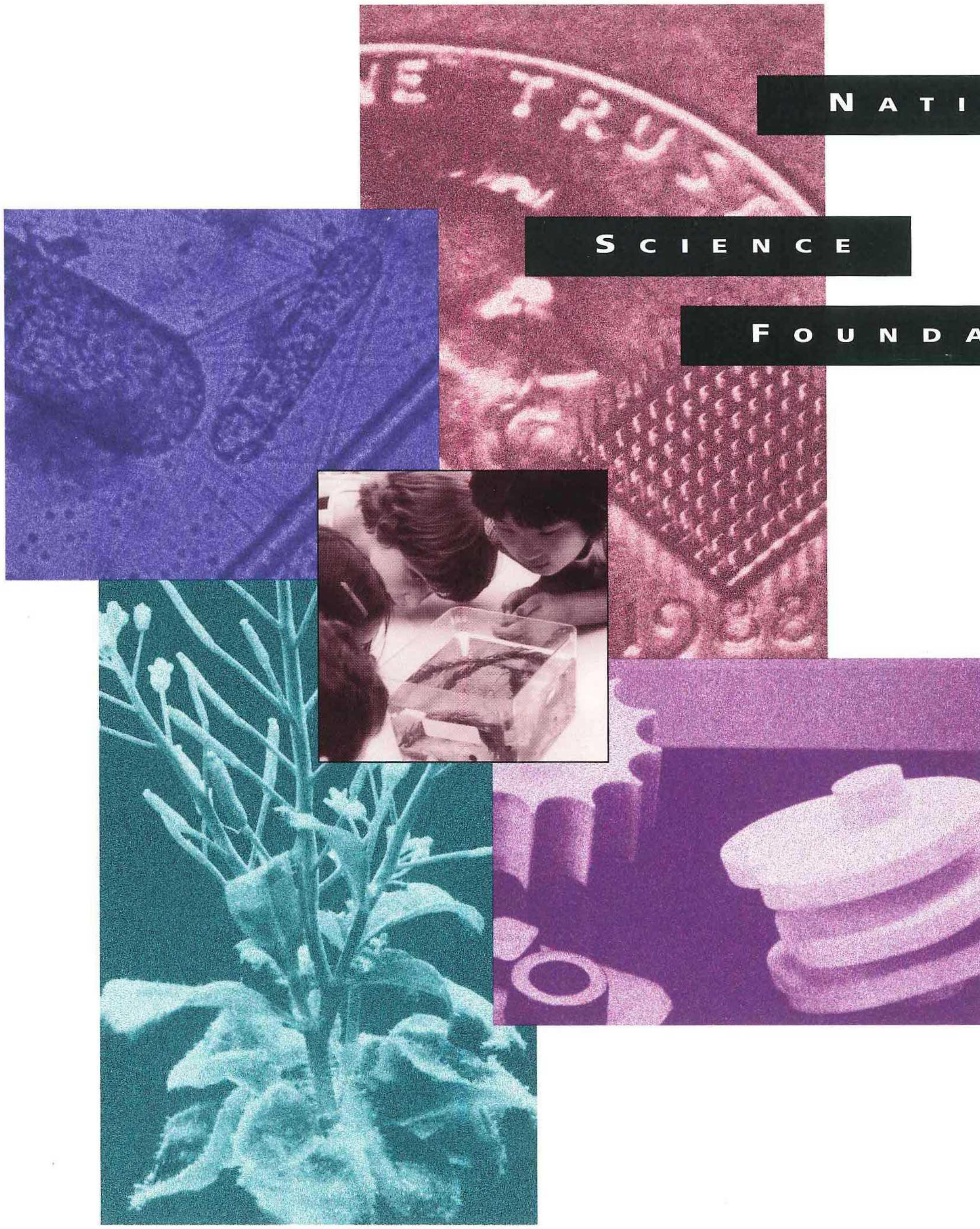
Mildred's copy

National Science Foundation



Annual Report 1992

About the National Science Foundation

The National Science Foundation is an independent federal agency created by the National Science Foundation Act of 1950 (P.L. 81-507). Its aim is to promote and advance scientific progress in the United States. The idea of such a foundation was an outgrowth of the important contributions made by science and technology during World War II. From those first days, NSF has had a unique place in the federal government: it is responsible for the overall health of science and engineering across all disciplines. In contrast, other federal agencies support research focused on specific missions, such as health or defense. The Foundation is also committed to ensuring the nation's supply of scientists, engineers, and science educators.

NSF funds research and education in science and engineering. It does this through grants and contracts to more than 2000 colleges, universities, and other research institutions in all parts of the United States. The Foundation accounts for about 25 percent of federal support to academic institutions for basic research.

NSF receives approximately 57,000 proposals each year for research, graduate and postdoctoral fellowships, and math/science/engineering education projects. It processes more than 20,000 award actions each year. These typically go to universities, colleges, academic consortia, nonprofit institutions, and small businesses. The agency operates no laboratories itself but does support National Research Centers, certain oceanographic vessels, and antarctic research stations. The Foundation also supports cooperative research between universities and industry and U.S. participation in international scientific efforts.

The Foundation is run by a presidentially appointed Director and Board of 24 scientists and engineers, including top university and industry officials.

NSF is structured much like a university, with grant-making divisions for the various disciplines and fields of science and engineering. The Foundation staff is helped by advisors, primarily from the scientific community, who serve on formal committees or as ad hoc reviewers of proposals. This advisory system, which focuses on both program direction and specific proposals, involves more than 59,000 scientists and engineers a year. NSF staff members who are experts in a certain field or area make award decisions; applicants get unsigned copies of peer reviews.

Awardees are wholly responsible for doing their research and preparing the results for publication. Thus the Foundation does not assume responsibility for such findings or their interpretation.

NSF welcomes proposals on behalf of all qualified scientists and engineers and strongly encourages women, minorities, and persons with disabilities to compete fully in its programs.

In accordance with federal statutes and regulations and NSF policies, no person on grounds of race, color, age, sex, national origin, or disability shall be excluded from participation in, denied the benefits of, or be subject to discrimination under any program or activity receiving financial assistance from the National Science Foundation.

Facilitation Awards for Scientists and Engineers with Disabilities (FASED) provide funding for special assistance or equipment to enable persons with disabilities (investigators and other staff, including student research assistants) to work on an NSF project. See the program announcement or contact the program coordinator at (202) 357-7562.

The National Science Foundation has TDD (Telephonic Device for the Deaf) capability, which enables individuals with hearing impairment to communicate with the Division of Personnel and Management about NSF programs, employment, or general information. This number is (202) 357-7492.

National Science Foundation Annual Report 1992

A retrospective of selected research funded by NSF

Washington, D.C.

DEAR MR. PRESIDENT:

I have the honor to transmit herewith the Annual Report for Fiscal Year 1992 of the National Science Foundation, for submission to the Congress as required by the National Science Foundation Act of 1950.

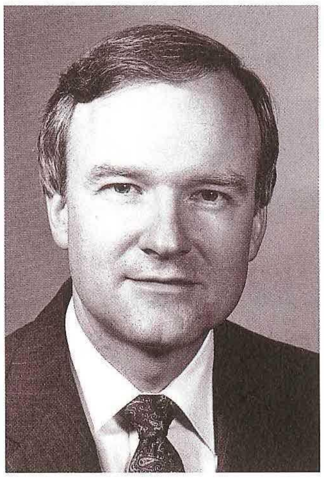
Respectfully,

Frederick M. Bernthal
Acting Director, National Science Foundation

The President of the United States
The White House
Washington, D.C. 20500

C O N T E N T S

FREDERICK M. BERNTHAL
ACTING DIRECTOR
NATIONAL SCIENCE FOUNDATION



Frederick M. Bernthal
Acting Director,
National Science Foundation

The pages of this report describe the wealth of activities that testify to the National Science Foundation's continuing contribution to the nation's overall capabilities in science and technology. Under its mission of promoting the progress of science and engineering, NSF provides support for a broad range of research and education activities in all fields of the physical, natural and social sciences, mathematics, and engineering.

America's capabilities in science and technology have long been a steady driver of economic growth, productivity gains, new job opportunities, rising living standards, and improved quality of life. Over four decades of investment in science and engineering at academic institutions by NSF and other Federal agencies have underpinned the development of a base of human resources and intellectual capital that is unmatched in human history. It is clear that the returns on this investment have been outstanding: the Congressional Budget Office noted in a recent report that "economic measures suggest generally high rates of return for basic research and academic research in science and engineering...."

All indications are that the importance of science and technology in determining our national well-being will only increase in the years ahead. Many areas vital to the nation's future -- from nurturing new industries with high-skill, high-wage jobs, to developing advanced, environmentally compatible manufacturing techniques, to creating faster, more efficient modes of transportation and information exchange -- require continued progress in fundamental research across a range of disciplines and the adoption of innovative, forward-looking approaches to education and training.

NSF recognizes and actually embraces these increasing expectations for benefits from investments in research and education. As an agency, we are focusing our efforts around new strategies that build on our past successes as well as define a new working relationship in science and technology between government, academe, and the business-industrial enterprise. Indeed, as is discussed later in this report, strategic planning took center stage at NSF in 1992 with the work of the Commission on the Future of NSF and the agency's own internal planning discussions. This work is reflected in the three strategies that have been developed to help guide the agency into the future.

- **Enhancing Fundamental Research Capabilities**. Strengthening the nation's overall capabilities in fundamental science and engineering will always be an overarching priority for the Foundation. The fundamental research activities supported by NSF have often been the source of unexpected advances, revolutionary insights, and new perspectives on old problems. One example, discussed in more detail later in this report, is of progress being made toward controlling the process of chemical bonding in multi-atom molecules, a problem that has long befuddled chemists. The NSF-supported research is still years from being applicable to industrial uses, but the potential is clearly evident.

  To provide the flexibility needed to pursue challenges at the frontiers of knowledge, NSF's research programs offer a variety of modes of support. NSF research grants range from small, short-term grants for exploratory work to traditional individual investigator awards to centers that involve researchers from both academia and industry. Additionally, the large-scale research facilities and information-processing capabilities supported by the Foundation — such as observatories, research vessels and aircraft, supercomputer centers, and advanced communications networks like the NSFNET — aid cooperation among researchers and build strong links between scientific research and technology development.

- **Investing in People**. Perhaps no strategy encompasses more of what NSF is and does than "Investing in People." Nearly every dollar spent by the Foundation is in some way an investment in the education and advanced training of individual members of society: research grants provide support for senior scientists and engineers, postdoctoral researchers, technicians, graduate students, and, in certain instances, undergraduate and high school students; in addition, programs under NSF's Directorate for Education and Human Resources reach schools, teachers, and students at all grade and achievement levels and in all regions of the country. In 1992, nearly 95,000 people were direct participants in NSF's programs, ranging from senior scientists working at major universities to precollege students attending science summer camps.

  Many of NSF's efforts to strengthen the nation's human resource base are highlighted in this report. The Foundation is involved in a variety of projects to improve all aspects of mathematics, science, and engineering education, including the Statewide Systemic Initiatives, Engineering Education

Coalitions, and the Alliances for Minority Participation. Furthermore, NSF also has a leading role in a larger, ongoing government-wide effort to improve and reform math and science education coordinated by the Federal Coordinating Council for Science, Engineering, and Technology.

- **Addressing Strategic Research Priorities.** Because the progress of science is closely tied to the application of new knowledge to the pressing concerns of society, strategic research on critical areas of national priority has become an integral part of the NSF portfolio. In 1992, NSF expanded funding for special research initiatives in such areas as high performance computing and communications, manufacturing, materials, global change, and biotechnology. As in math and science education, these research initiatives are undertaken in close cooperation with other Federal agencies, which reduces unnecessary redundancies and increases the overall effectiveness of the public's investment.

Through these initiatives, NSF supports fundamental research that is crucial to furthering progress and generating benefits on a societal level. Emphasis is also given to activities that promote cooperation across disciplinary lines and between different sectors of the economy, notably academia, industry, and government. For example, the High Performance Computing and Communications Initiative represents a unique public/private partnership that both addresses major research challenges and helps to create more efficient access to information for all members of our society. Similarly, in the area of global climate change, NSF supports research that examines not only the scientific basis of the phenomenon but also its potential human impacts and policy implications.

In summary, 1992 saw NSF continue to fulfill its central role in strengthening the nation's capacity to excel in science and technology. This is a proud tradition for the Foundation -- one that has been and remains immensely valuable to the nation. And, with guidance from thoughtful and circumspect strategies, there is every reason to believe that it will carry forward into the future.

Developing Human Resources

Improving education in science, mathematics, and engineering is a major national goal. Well-trained students are the backbone of new knowledge generation, technology transfer, and leadership for the future. Moreover, in a society that is increasingly oriented toward technology, a basic understanding of science and mathematics is essential for a technically competent workforce and well-informed citizens.

NSF, through its Education and Human Resources directorate and other agency programs, has been supporting a variety of projects to improve all aspects of science and mathematics education (including systemic reform across several states); to encourage more students to take technical subjects; and to increase the involvement of groups now underrepresented in high-tech fields (women, minorities, and persons with disabilities). NSF projects range from high school teacher awards and museum or media programs to lab improvement for undergraduates to fellowships for graduate students, postdoctoral grants, and many more activities. Following are a few examples.

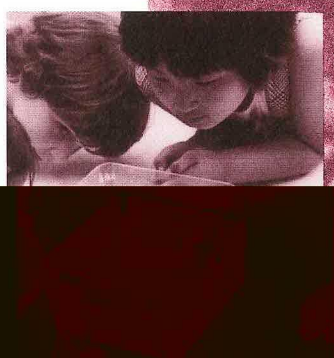
REFORM EFFORTS

At the heart of current efforts to improve U.S. science and mathematics education is curricular reform, joined by teacher preparation and enhancement activities. NSF has been supporting development of new curricula that encourage students to seek knowledge out of interest, rather than from a demand for rote learning. Using these new materials, teachers become facilitators and coaches, not just lecturers. The Foundation has, for example, funded several mathematics curriculum projects, including three at the elementary level, five in middle school, and, in 1992, four at the secondary level.

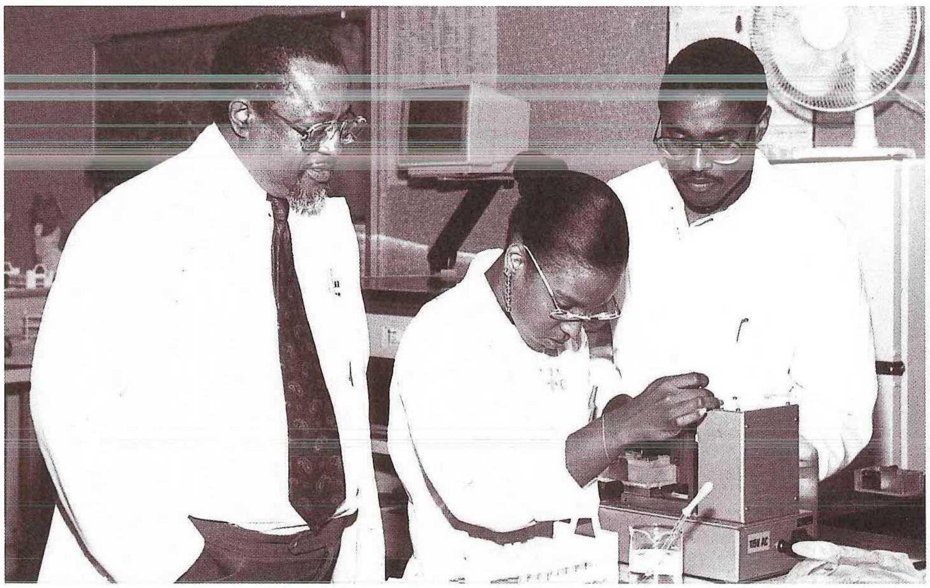
The commitment to provide new science teaching materials also is illustrated by NSF's early support of "Chemistry in the Community" (ChemCom). This high school chemistry course, developed by the American Chemical Society, presents basic chemistry principles in the context of society's problems. Thus it appeals to students whether they are scientifically inclined or not; some 400,000 students in the United States and 50 foreign countries have used ChemCom. NSF has also supported physics and biology courses similarly organized around real-world themes.

A key curriculum and teacher training activity is Project IMPACT in Montgomery County, Maryland. This is an ongoing effort in six elementary schools where students scored low on standardized tests. Preliminary data show

NSF supports development of new curricula and curriculum reform...teacher training activities... and new ways of teaching and learning.



that students at IMPACT schools have done well on tests of various math skills, compared to students from other county schools. IMPACT teachers are trained to engage students in their own learning, tailor lessons to different learning styles, and stress the use of hands-on materials.



Continued learning. The work of these Meharry Medical College students, shown working with a faculty member, is funded through NSF's Minority Research Centers of Excellence. (Photo copyright: John C. Streator, Jr.)

NSF support for curriculum reform also extends to the undergraduate level. In the summer of 1992, more than 3,500 faculty participated in short courses and workshops to help them improve and update their undergraduate courses. In the fall, an estimated 4,000 undergraduate students were enrolled in calculus courses that were significantly revised to involve more group learning, more open-ended and extended problems, more applications from other disciplines, and the appropriate use of technology. An introductory physics course has been developed that replaces traditional lectures and laboratory exercises with the exploration of physical phenomena enhanced by the use of microcomputers for data collection and problem solving.

With NSF support, the physics community—through the American Institute of Physics—is developing new models for undergraduate introductory courses. The models incorporate topics in contemporary physics that working physicists use in their work, knowledge of how students learn physics best, and appropriate modern technology.

In any year, about 300,000 undergraduate students are participating in one of 3,000 teaching laboratories that have been recently improved by the addition of new instrumentation. The laboratories include new experiments and new ways of teaching and involving undergraduate students in science, engineering, and mathematics.

In engineering, NSF is supporting new ways of teaching and learning. NSF has launched a series of engineering education coalitions designed to (1) reach out to minority students, *NSF funds a variety of programs to encourage minority students, females, and persons with disabilities to pursue science and math.*

(2) teach engineering students to integrate knowledge from many disciplines, and (3) teach students to work in teams. Each coalition consists of about ten institutions working together. One goal is to bring together students and faculty with diverse backgrounds. For example, one coalition includes New York City's Columbia University and Florida International University of South Miami, which has a largely Hispanic enrollment. In this manner, students from each school are exposed to different types of engineering problems and different perspectives on solutions.

Another major reform effort is the Statewide Systemic Initiative (SSI). This initiative is designed to encourage improvements in science, mathematics, and technology education through comprehensive systemic changes in the education systems of the states. To be truly systemic, states must have commitment from the Governor and other leaders and develop a shared vision of mathematics and science education including: curriculum goals, instructional strategies, student assessment, changes in school structure and decision-making, plans for addressing equity, and professional development.

Built on solid models of change, SSI initiatives provide new direction for mathematics and science education, demonstrate the broadest involvement of key players, and make maximum use of state and local resources. Twenty-one states are currently funded by the program: California; Connecticut; Delaware; Florida; Georgia; Kentucky; Louisiana; Maine; Massachusetts; Michigan; Montana; Nebraska; New Mexico; North Carolina; Ohio; Puerto Rico; Rhode Island; South Dakota; Texas; Vermont; and Virginia.

SSI states receive substantial technical assistance with strategic planning, curriculum development, assessment, and staff development. There is also a multi-year evaluation to determine the effectiveness of strategies for change, the extent to which significant policy changes occurred, the achievement of students, and the improvement of teachers and schools.

ASSESSMENT OF LEARNING

In the area of testing and assessment, a three-year Boston College study funded by NSF showed that standardized and textbook tests given to most U.S. students adversely influence the teaching of math and science skills. The researchers said that this

Science and math on TV. Astronaut Bonnie Dunbar tells "Futures" students and host Jaime Escalante that math is the backbone of her work. "Futures" is an award-winning public television program on math applications, supported in part by NSF. Jaime Escalante is the math teacher featured in the 1988 film "Stand and Deliver."

finding is especially true in classrooms with high minority enrollments.

According to George Madaus, the study's principal investigator, the tests studied overwhelmingly emphasize low-level skills such as rote memorization and recall, rather than high-level skills such as conceptualizing, problem-solving, and reasoning.

The researchers surveyed more than 2,200 math and science teachers nationwide, and interviewed more than 300 teachers and administrators in six urban sites across the country. Results of the study describe a serious gap between district/state testing policies and teachers' professional judgments, and they indicate a need for policymakers to integrate teacher opinions when designing policy that affects classroom instruction.

WIDER ACCESS FOR UNDER-REPRESENTED GROUPS

To increase the numbers of minority scientists, engineers, and educators, NSF has funded a variety of programs to encourage minority students at all levels to study science, math, and engineering. These activities include:

- Student development activities ranging from summer science camps for pre-college youth to graduate fellowships and traineeships.
- Awards to fund undergraduate faculty and students at minority institutions, purchase equipment for those institutions, and help upgrade their research facilities.
- Partnership efforts such as Alliances for Minority Participation, which involve academia, business, national labs, and government agencies. These public-private coalitions are designing such activities as undergraduate student enrichment, curricula improvement, and efforts to enhance minority educational institutions. Another partnership—with similar aims but focused on precollege youth—involves academia, business, and community leaders working in Comprehensive Regional Centers for Minorities.

At the graduate school level, NSF's Minority Research Centers of Excellence program has opened up new opportunities. NSF support has enabled eight of the most research-productive minority institutions in the United States to open new graduate programs in several fields of specialty.

For example, Hampton University in Hampton, Virginia, now has a doctoral program in nuclear physics; Meharry Medical College in Nashville, Tennessee, offers membrane science; and graduate students at the University of Texas, El Paso, can earn degrees in materials science.

In September 1992 an NSF-sponsored national conference on "Diversity in the S&T Workforce" met in Washington, D.C., to address the issue of greater minority involvement in the science and engineering enterprise. The gathering drew more than 900 representatives from academic, corporate, and government sectors as it highlighted current minority education issues in science, engineering, and mathematics.

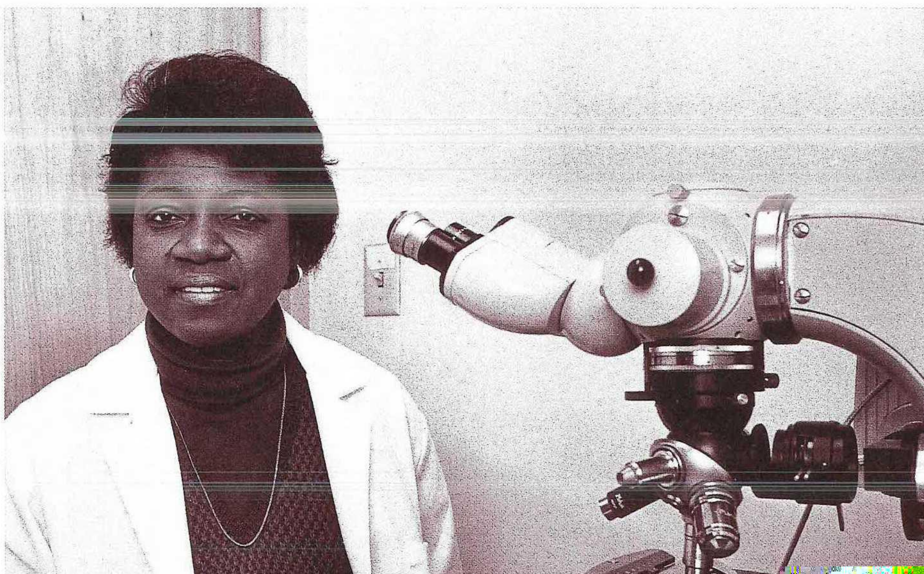
The conference also showcased successful programs and research presentations by more than 250 students involved in NSF-sponsored research projects. Panel discussions focused on a national action plan for the year 2000 and beyond—one that would guide NSF efforts to upgrade science and technology education for minorities.

Efforts to encourage females to pursue science and math begin in the early years and continue through college and career. An example of NSF support in the college period is the Women in Science Project (WIS) at Dartmouth College. Through internships, peer mentoring, and special

The Foundation also encourages persons with disabilities to pursue science. For instance, NSF may fund special equipment, such as computers with large-font type, braille, or voice synthesizers. For the motor-impaired, there are voice-activated computers. Supplemental grants for special equipment or other assistance are available to NSF-funded researchers who hire physically disabled staff on their projects, including student research assistants.

The Foundation also promotes instructional materials and media that are accessible to people with sensory, physical, and perceptual disabilities; supports model programs for students with disabilities; and encourages science and mathematics teachers to develop the full potential of those students.

seminars, this project has encouraged college women to major in engineering, math, and science. According to a late 1992 Dartmouth survey, those involved in WIS were more than twice



reach to precollege students), mentoring, and giving guest lectures. In fiscal 1992, 22 women were funded through the VPW program; some 280 female scientists have been supported since the program began.

Other NSF career-oriented programs for women include Research Planning Grants (to strengthen proposal writing and related skills) and Career Advancement Awards (for experienced researchers, including those whose careers have been interrupted or otherwise changed direction).

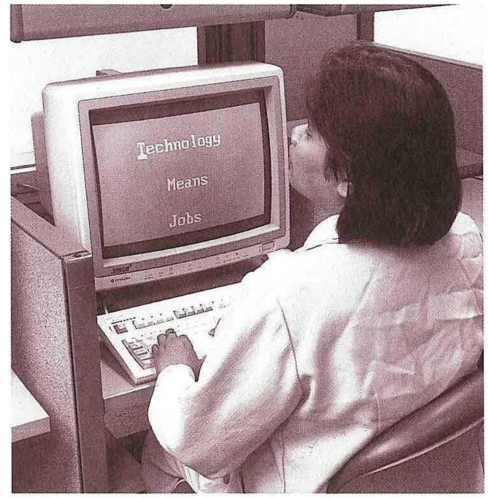
PUBLIC UNDERSTANDING

NSF works to broaden public

affected sea creatures and human residents of coastal Alaska.

The exhibit features more than 100 color photographs, artifacts from the spill, and several interactive elements. "Darkened Waters" originated in June 1989 with a small photographic exhibition at the Pratt Museum in Homer, Alaska; NSF funding allowed Pratt to expand the exhibit to a larger size with more elements. After April 1992, "Waters" became a three-year traveling exhibit managed by the Association for Science and Technology Centers.

Another unique exhibit funded by NSF allows museum visitors to explore psychological processes—thoughts, feelings, and attitudes. It is a hands-on exhibition developed by the American Psychological Association. Entitled "Psychology: Understanding Ourselves, Understanding Each Other," the exhibit is designed to introduce visitors to the breadth, depth, and diversity of more than 100 years of psychological research. Starting in May 1992, the show began a tour of nine science museums throughout the United States.



Large-font computer. This instrument enables use by people with poor vision.

PROBING THE GLOBAL ENVIRONMENT

Public concern about the global environment continues, and the geosciences—like education—are a key research area for NSF. Scientists seek to learn more about the world's ecology; the Foundation supports investigations into earth, oceanic, and atmospheric sciences, along with a focus on the polar regions. Following are a few sample projects.

OCEAN FLOWS AND CLIMATE CLUES

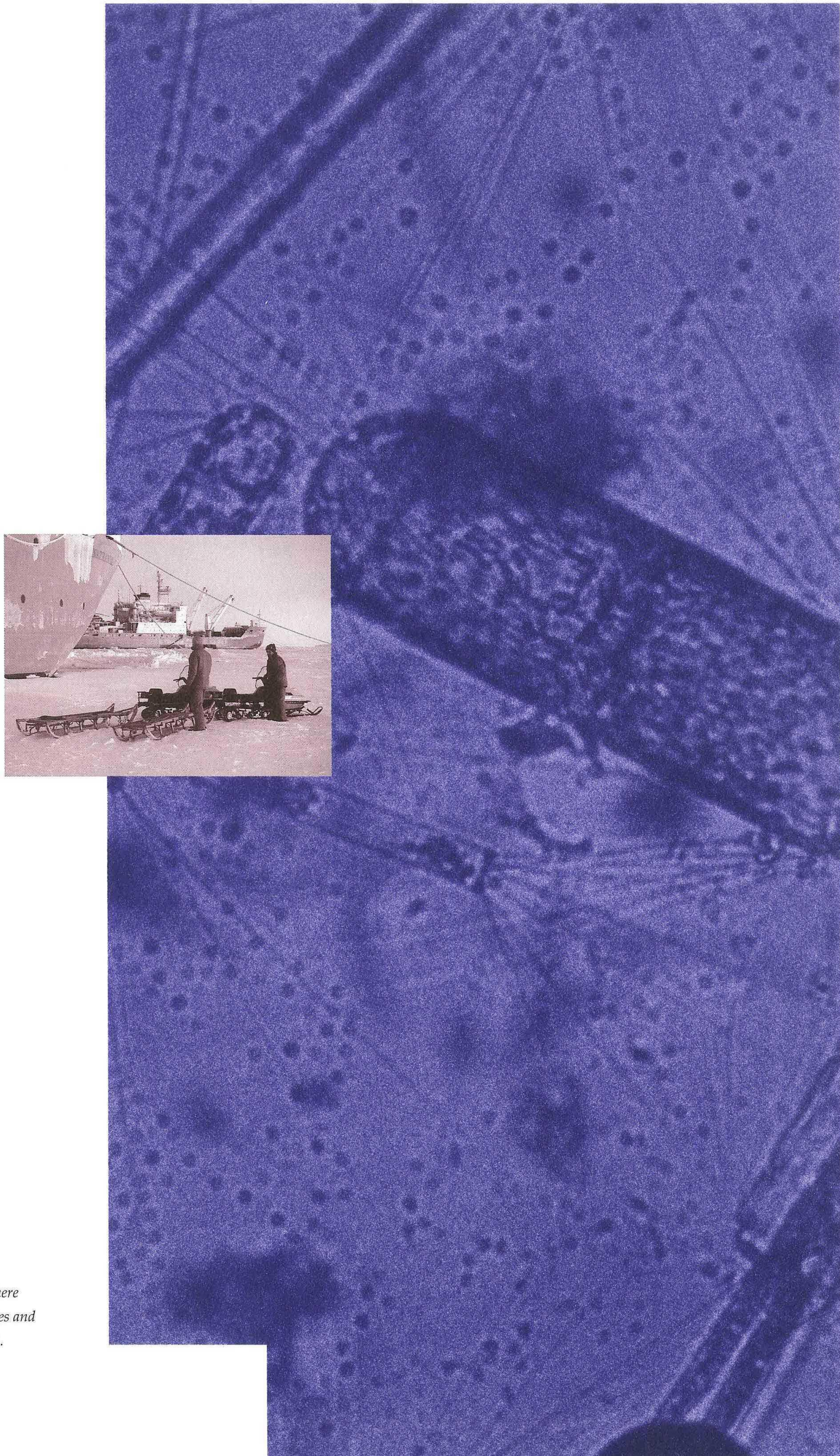
Through the World Ocean Circulation Experiment (WOCE), scientists have been seeking to describe and model ocean currents. Better understanding of ocean circulation is critical to predicting warming and cooling trends, as well as other global scale changes.

A major modeling initiative for the North Atlantic Ocean has been completed, followed by testing of global circulation models. A field survey of the Pacific Ocean was launched, with an even more comprehensive study of the Indian Ocean to follow. These efforts involve many nations, cooperating by sharing resources, data, and scientific expertise. The next steps are to synthesize the data into global models in order to compare the models with one another and test them for accuracy.

NSF-sponsored researchers have been studying the polar oceans as well. Water migrating into these regions releases large quantities of heat, carbon dioxide, and other gases; thus polar oceans contribute greatly to regulating climate. One innovative and daring study focused on formation of the oceanic currents that flow from Antarctica's Weddell Sea to the North Atlantic. Researchers from the United States and the Former Soviet Union set up their scientific station on an ice floe in the sea.

In the Weddell Sea, cold water sinks to the bottom, forming the oceanic currents there. The researchers found that at different places along the continental shelf and slope, the mechanism of flow formation varied. These findings are expected to alter estimates of the amount of heat exchanged with the atmosphere, which could in turn change predictions of both short-range weather and long-term global change.

NSF-funded scientists also have looked for clues to regional and global climate change deep beneath the surface of Siberia's Lake Baikal, the world's largest and deepest freshwater lake. A field team of scientists from the Woods Hole Oceanographic Institution, U.S. Geological Survey, and the University of Rhode



The Foundation supports investigation into earth, oceanic, and atmospheric sciences, along with a focus on the polar regions.

Ice camp. Supply ship arrives at Antarctic floating ice station, where researchers from the United States and the Former Soviet Union worked.

Better understanding of ocean circulation is critical to predicting warming and cooling trends, as well as other global scale changes.

Island acquired an initial group of sediment cores from the lake bottom in 1991, using a special piston coring system designed by Woods Hole researchers. The cores provide information on continental response to glaciation, deglaciation, and cooling and warming periods in the earth's history. An ice-based drilling rig takes core samples from January through April, with additional samples collected by ships during the summer months. Scientists have compared the cores from Lake Baikal to those taken in other lakes, the ocean, and ice sheets in an effort to understand regional and global changes in climate since the last ice age (some 18,000 years ago).

Transoceanic telecommunications cables, which are broadly distributed in the Atlantic and Pacific Oceans and in marginal seas, may present a unique opportunity for data acquisition over a large area of the ocean. Although the primary focus of efforts to find new uses for transoceanic cables has been basic research, it may be possible to use these cables to monitor geologic, atmospheric, and oceanographic elements of climate change. The cables could be fitted with sensors that would provide "real-time" information on ocean surface winds, waves, and rainfall. These data could then be used for independent verification of satellite data, and for long-term global monitoring of atmospheric and sea-surface changes.

COOL CLOUDS, GASES, AND FOSSIL RECORDS

Besides the oceans, atmospheric water contributes to modulating climate. Using modern remote sensing techniques, researchers at the University of Utah discovered that within cirrus clouds (the highest, at about 10,000 meters) water droplets had been supercooled—to -48 degrees Celsius. This finding has implications for climate change, since the quantity of sunlight reflected into space from watery clouds is different from that reflected by icy clouds.

The researchers suggested that sulphate particles, possibly produced by the 1992 eruption of Mount Pinatubo in the Philippines, may act as condensation nuclei and in solution may depress the freezing point of water to produce supercooled droplets.

Another way scientists study global change is through monitoring temperature and concentrations of such trace gases as carbon dioxide and methane, so-called "greenhouse" gases. Their increasing concentrations as a result of human activity can cause a global warming in the lower atmosphere; they have a much larger, and easily measurable, cooling effect in the tenuous upper atmosphere. To get baseline data on the gases, scientists have been deploying upgraded monitoring instruments located from the equator to the poles. This effort, scheduled to be completed within the decade, will provide an early warning system on global evolution.

Yet another perspective on current global change comes from investigating historical patterns of weather and pollution. Such information is preserved in ice sheets. During 1992 researchers working in Greenland drilled down beyond 2,200 meters, reaching ice that formed 42,000 years ago. Among the year's discoveries:

- A number of very rapid climatic transitions, of several degrees Celsius, occurred between 14,000 to 11,000 years ago. These abrupt warmings and coolings took place over periods of less than two decades.
- Atmospheric pollutants were virtually absent prior to the industrial era.

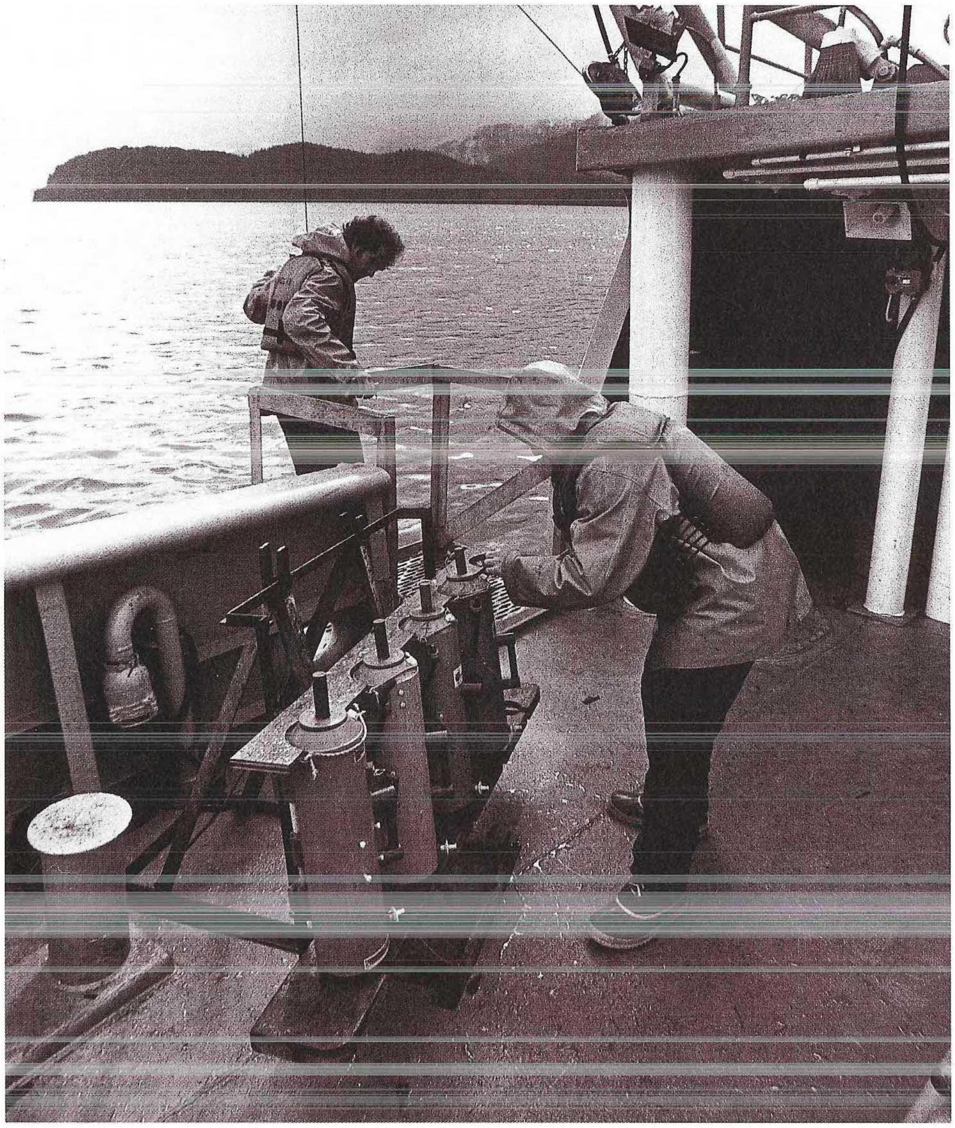
Institutions involved in this research include the U.S. Army's Cold Regions Research and Engineering Laboratory, the University of New Hampshire, the University of Rhode Island, and the Desert Research Institute at the University of Nevada.

Animal life also offers clues to climate change. Responding to temperature differences in a variety of native habitats, closely related species of fish have evolved large differences in their abilities to tolerate fluctuations. Scientists seek to understand the molecular basis for this phenomenon. At this writing, they believe that differences between the structures of key temperature-sensitive metabolic enzymes are somehow responsible. Ongoing research could help us understand how organisms adapt to changing temperatures—knowledge that might prove useful in dealing with global warming.

AREAS OF CONCERN

Increased mid-ultraviolet (UV-B) radiation—resulting from the widening of the South Polar ozone hole—caused a 6 to 12 percent decline in phytoplankton production in Antarctic waters during the austral spring of 1992. Separate research at McMurdo Sound indicated a 15 percent decline in marine phytoplankton there. Phytoplankton are tiny plants at the base of the oceanic food chain; fish, penguins, and all other animals depend upon these plants.

Meanwhile, yet another threat to the ozone layer has been identified by



Coastal research. To gather knowledge that may help predict damage to U.S. costal regions, marine science graduate students use Niskin bottles to sample seawater at various depths. Credit: Sabra McCracken

the NSF-supported National Center for Atmospheric Research: 15 to 30 million tons of sulfur dioxide from the 1992 eruption of Mount Pinatubo in the Philippines. As a result, NCAR scientists predict that ozone levels could decline 10 percent in the temperate latitudes of our own northern hemisphere and much more than that over the poles.

Currently in the United States, human activity may be putting the greatest environmental stress on the coastal regions—already vulnerable to damage from hurricanes such as those that devastated parts of Florida, Louisiana, and Hawaii in 1992. Today 43 percent of the U.S. population lives in coastal counties. Projections suggest that within 50 years that number could increase by 50 million. Pollution from fertilizers, industrial waste, and sewage will further affect fisheries, and human development is displacing coastal habitats, leading to species extinction in some cases.

Funded in the summer of 1992, an NSF program called CoOP (Coastal Ocean Processes) is focusing on the biology, chemistry, and physics of coastal oceans—knowledge that will help researchers predict likely damage before it occurs and offer options to policy makers. The National Oceanic and Atmos-

Deep beneath the surface of the world's largest and deepest freshwater lake, NSF-funded scientists have looked for clues to regional and global climate change.

pheric Administration (NOAA) and the Office of Naval Research are also collaborating in this research.

Great progress in instrumentation during the 1990s has brought an unprecedented opportunity for major advances in the scientific understanding of storm-scale weather phenomena. For example, a new wind profiler can sample wind speed and direction every six minutes, from earth's surface to altitudes of 15 to 20 kilometers—a vast improvement over the old balloons that could provide data just twice a day.

The U.S. Weather Research Program — a partnership among NSF, NASA, the Environmental Protection Agency, and the Departments of Commerce, Transportation, Defense, Energy, and Interior — intends to capitalize on these new instruments and recent advances in fundamental knowledge and numerical modeling. As stated in the multi-agency strategy document, "Predicting Our Weather," the broad goal of this program is to advance basic understanding of weather and to enhance weather services provided to the nation.

The winter of 1992 saw the completion of what will be the first of a series of Weather Research Program field experiments. This project, known as the Stormscale Operational and Research Meteorology-Fronts Experiment, Systems Test (STORM-FEST), focused on winter frontal storms and accompanying precipitation — rain, freezing rain, snow, and sleet. Objectives were a preliminary investigation of the development and evolution of winter storms, along with testing and evaluating the new observational systems and numerical prediction models.

Initial impressions were that the new data systems, coupled with advanced research numerical models, resulted in significant improvements in simulating the timing, location, and amount of precipitation. Such accurate simulations are important to both the research and operational communities.

Frontiers of Knowledge: Basic Research

Along with education, NSF's chief mission is to support research in science and engineering. This research can lead to applications such as those described in the next chapter. Following are examples of basic research in a broad range of NSF-supported areas during fiscal 1992.

PLANT GENOME PROJECT: SECOND YEAR OF PROGRESS

Arabidopsis is a simple weed, but for researchers its simplicity is a virtue that makes it a wonderful choice for genetic research. It has spawned an international collaboration among plant scientists, who share information, ideas, and advice on research via a global electronic bulletin board. Several efforts on systematic sequencing of the plant's genome were initiated during FY 92. This was considered an unrealistic goal two years earlier, but is now possible because of advances in sequencing technologies.

The ultimate goal of this genome research project is to understand the physiology, biochemistry, growth, and developmental processes of a flowering plant at the molecular level, using Arabidopsis as an experimental model system. The project, which began in 1990, is coordinated by a nine-member steering committee of Arabidopsis researchers around the world. NSF is the leading source of U.S. funds for the project.

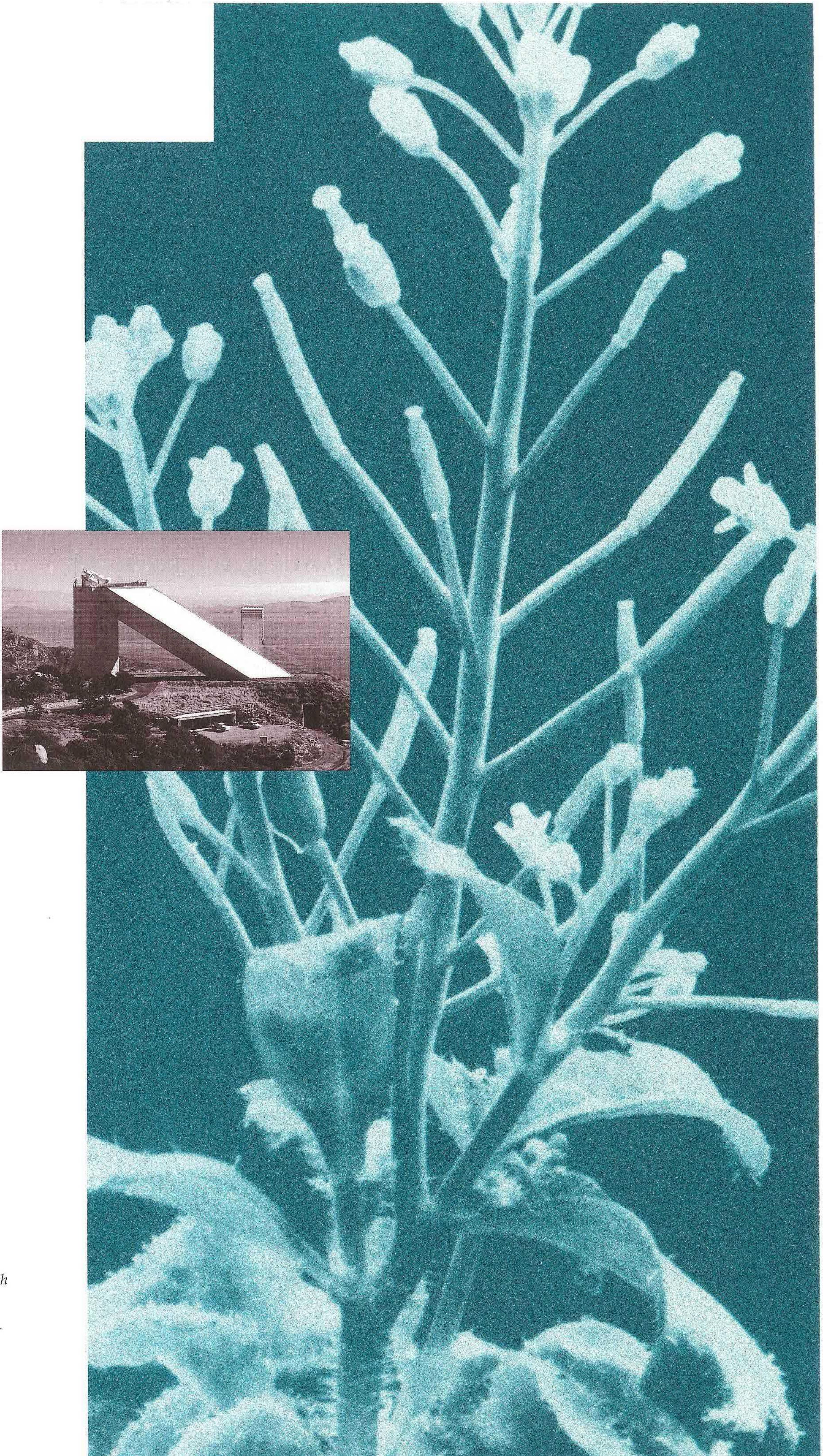
Continued progress has been made in constructing a physical map, in identifying and characterizing new mutations, and in producing genes identified and cloned. A notable example is the use of **Arabidopsis** to study disease resistance mechanisms at the genetic and molecular levels. There has been rapid progress in identifying and characterizing genes that are involved in resistance or susceptibility of the plant to bacterial, fungal, viral and other pathogens.

This research is integrated into general genome and plant biology research activities. Major progress on many genetic questions has been made using **Arabidopsis** as a model system, and researchers anticipate future application of these advances to improving plants of economic significance.

CHEMISTRY AND MATERIALS RESEARCH

Chemists at Stanford University—under the direction of Richard Zare—have demonstrated, for the first time, controlled cleavage of either of two bonds in a three-atom molecule. The bond-specific chemistry was performed on HOD (hydrogen-oxygen-deuterium), a water molecule that has a deuterium atom sub-

Whether exploring sulfide-spewing vents on the sea bed or cosmic particles and gravity waves arriving from the vast reaches of the universe, scientists must constantly invent and refine the instruments they use.



Arabidopsis. This simple weed is the subject of an international genetic research effort.

Inset photo: Solar scope. The McMath Solar Telescope on Kitt Peak, near Tucson, is a key instrument in astronomical research.

stituted for one of the hydrogen atoms. This molecule can react with an energetic hydrogen atom in one of two

and release an epoxylike sealant. The "passive" smart material reacts automatically without the need for

Michigan in Ann Arbor, has been developing the underlying physics and the technology with NSF backing. The Center has worked with more than fifteen international and local companies, and industry researchers involved with this effort have started two new companies in Ann Arbor.

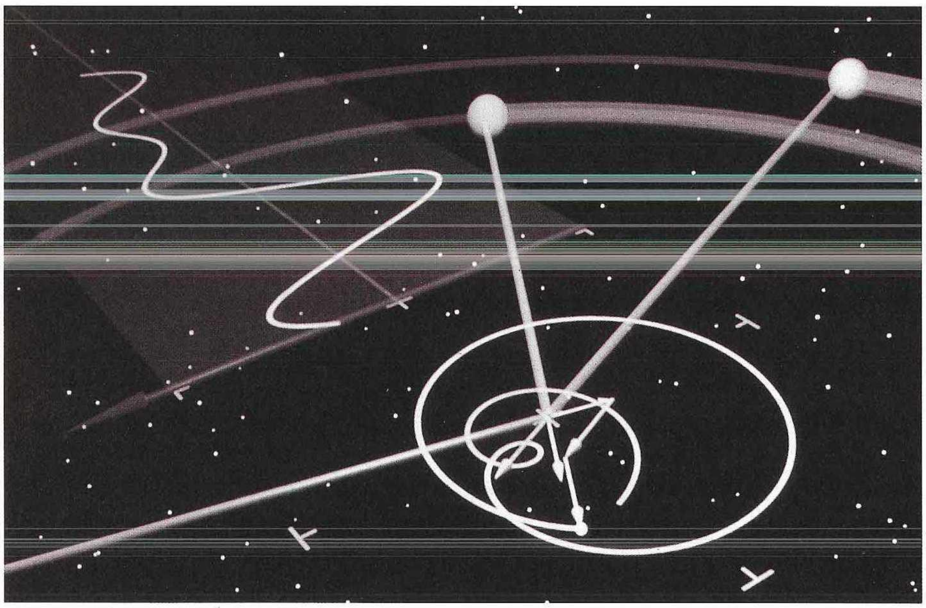
Using the Arecibo Observatory's radio/radar telescope, an astronomer has discovered the first planets outside of our own solar system. This finding is especially surprising because the planet formation occurred much differently than in our system. The planets circle a neutron star—an extremely dense and tiny body, about 16 kilometers in diameter, that resulted from a supernova. Astronomers believe there were two stars circling each other prior to the supernova, and that the planets were formed from the gases of one star vaporized by the explosion.

Astronomers at the National Radio Astronomy Observatory in Charlottesville, Virginia have discovered the first evidence of a cloud of molecular gas from a very distant galaxy that appears to be a reservoir of material from which second-generation stars are forming. The new observations indicate that second generation star formation is preceded by the accumulation of an enormous reservoir of molecular gas—residue from a

Charles S. Peskin and David M. McQueen of the Courant Institute have developed computer solutions to sets of differential equations that model the anatomy of the aortic valve. The equations are derived by considering the mechanical equilibrium of a system of fibers under tension that is supporting a pressure load. These equations may be solved to determine the structure of the valve leaflet and the arrangement of the collagen fibers that give it its strength. The computed fiber architecture has a branching, braided character that is startlingly reminiscent of the arrangement of collagen fibers in the real aortic valve.

In this research, the scholars use mathematics and computing to determine the detailed structure of the aortic valve. The work was accomplished at the Courant Institute with support for the Science and Technology Center in Geometry at the University of Minnesota. Some of the computation was done at the Pittsburgh Supercomputing Center.

now dead first generation of stars. The mass of the gas in the cloud is ten times the mass of the entire Milky Way galaxy.



New planets. In an artist's conception, the first planets to be detected outside of our solar system are circling a neutron star. Arrows indicate direction of physical forces.

HIGH-PERFORMANCE COMPUTING: CHANGING THE WAY SCIENCE IS DONE

The traditional scientific processes of experiment and theory have been augmented by a third—computational science, an amalgam of both. Using simulation as a tool, researchers drawing on the NSF-supported Supercomputer Centers have made significant contributions in many diverse fields, accelerating the solution of important practical and scientific problems. One example is reproducing the complexity of the surface structure of silicon. A computational model consisting of 700 atoms closely resembles microscopic images produced in the laboratory and permits deeper understanding of the way defects in materials affect their atomic structure and properties. This is of immediate significance because silicon is the key component currently used in the semiconductor industry.

Yet another use of high-performance computing is to develop electronic libraries that combine the immense storage capabilities of digital information with expert systems, now being developed. The object: allow users to retrieve information and access special knowledge bases without forcing them to become skilled search designers.

A prototype built at the Virginia Polytechnic Institute in Blacksburg, Virginia, during 1992 could initially store the equivalent of about 275,000 pages of text. The next objective is to raise its capacity to more than eight million pages. This system also has a large font display to aid users who are visually impaired.

The ability to integrate information from different kinds of databases may help to advance science and its applications. For example, NSF has been sponsoring work on an interactive computation system that involves communications network research, computer visualization, and medical treatment planning. At the University

Along with education, NSF's chief mission is to support research in science and engineering.

of North Carolina in Chapel Hill, clinicians have been using this system to customize radiation treatment for cancer patients, and to obtain immediate feedback on the results of changes in treatment plans. Bell South, GTE, and the Microelectronics Center of North Carolina have been collaborating on this project.

To make such information and knowledge tools available to scientists and engineers everywhere, NSF has been upgrading and expanding NSFNet. This computer network allows researchers anywhere in the United States to communicate and share resources with their peers worldwide and to operate equipment from afar, without leaving their offices. Examples include the remotely controlled optical telescope on Mauna Kea in Hawaii, the Fermilab particle accelerator in Batavia, Illinois, and the Human Genome Project in Baltimore, Maryland.

During fiscal 1992, the number of host computers on the NSFNet grew to nearly one million, and the number of U.S. colleges and universities connected to the network reached nearly a thousand. Medical campuses have been coming on line, and the first agricultural extension service has been hooked up. By the end of the fiscal year (September 30, 1992), NSFNet was connected to 6,500 other networks in 60 countries.

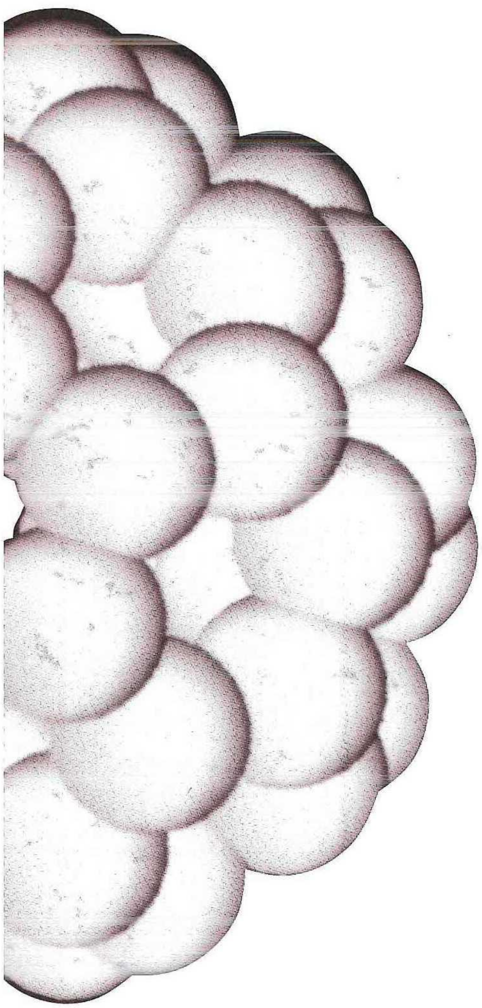
OTHER INSTRUMENTATION

Whether exploring sulfide-spewing vents on the sea bed or cosmic particles and gravity waves arriving from the vast reaches of the universe, scientists must constantly invent and refine the instruments they use. Some recent explorations made possible by special instrumentation are described below.

In an underwater feat, researchers aboard the submersible Alvin were able to take cores of active seafloor "black smokers" (small hydrothermal vents) for the first time, thanks to a unique diamond bit drill. The three-person Alvin, the country's premier submersible, can dive nearly four kilometers below the surface.

Previous efforts by Alvin scientists trying to take cores of hard materials on the seafloor had failed because earlier coring tools lacked adequate rotational speed and cutting ability. The new diamond bit drill was developed by a University of South Carolina geologist seeking to measure growth rates of seafloor sulfide deposits.

Based on information from the cores, the scientists concluded tentatively that individual black smoker



Buckyballs. Named for the late Buckminster Fuller (their shape bears a strong resemblance to geodesic domes that he popularized), these are models of pure carbon compounds. Only recently discovered, these compounds are the subject of new materials research. One example is a perfectly round buckyball cluster, containing 60 carbon atoms, the first "Buckminster Fullerene" to be discovered. Another is a bucky tube containing 210 carbon atoms, believed to be an extremely rigid structure.

chimneys in the Juan de Fuca Strait area (between Vancouver, Canada and the state of Washington) form rapidly, and that these active chimney structures are less than two years old.

In a totally different environment, NSF-supported scientists in Antarctica have been able to expand their research with a new icebreaker/research vessel, the **Nathaniel B. Palmer**. It has more than 600 square meters of research space, including laboratories, specialized computer and electronics facilities, and state-of-the-art acoustical systems, including equipment for seismic recording and precise navigation.

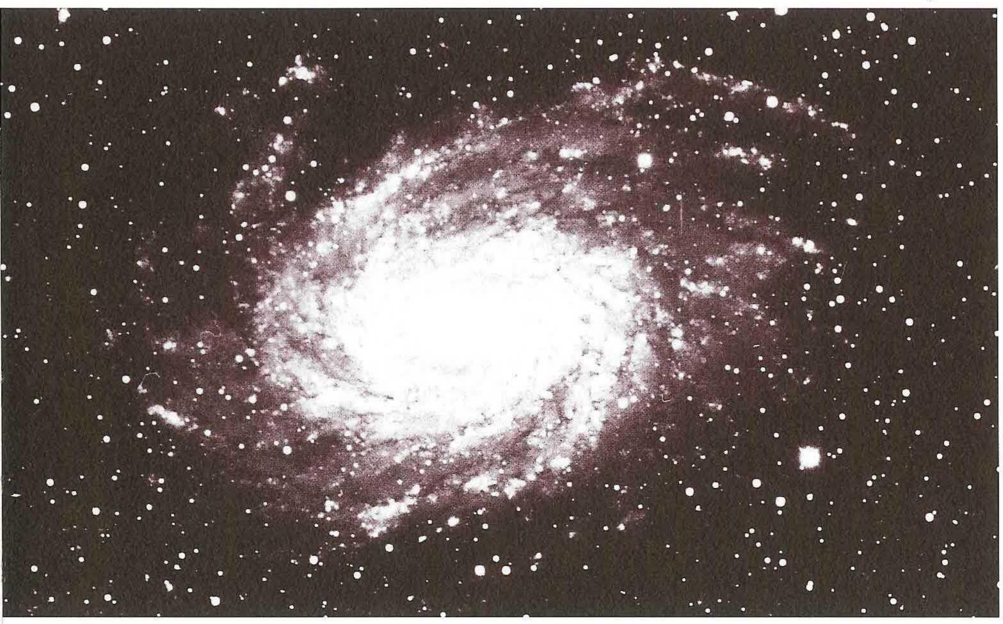
In astronomy, an NSF-funded researcher has used fiber optics to combine the light from two telescopes, making in effect a new, larger telescope. Steve Ridgway at the National Optical Astronomy Observatories in Tucson, Arizona, announced the results of an experiment performed at the McMath Solar Telescope on Kitt Peak, near Tucson. The breakthrough has important implications for designing the next generation of large instruments of this type.

Using the two auxiliary telescopes at McMath, equipped with a fiber optic system, Ridgway was able to observe stars in the constellations Orion and Taurus. The two instruments are separated by 5.5 meters, or about 18 feet; each has a diameter of 0.9 meters (36 inches). By combining light from them, the astronomer was able to attain nearly the resolving power of a telescope with a diameter of 5.5 meters.

Another type of universe explorer is the Laser Interferometer Gravitational Wave Observatory (LIGO), designed to detect gravity waves, a crucial prediction of Einstein's general theory of relativity. If gravity waves exist, the LIGO will enable astronomers to observe heretofore undetectable events and structures such as the collapse to a black hole or the coalescence of neutron stars.

The LIGO must be extremely sensitive, because gravitational waves will be incredibly weak. The device will incorporate many systems designed at new levels of precision and accuracy, including lasers, optics, and technology for vibrational isolation. Such developments will have many practical applications.

Since two detectors are needed to confirm the existence of gravitational wave events, the United States is building one in Hanford, Washington, and another in Livingston, Louisiana. More than two detectors would be needed to determine the direction from which gravity waves arrive on earth; thus the United States will collaborate with scientists in France, Italy, England, and Germany, who are pursuing similar research.



Far and away. Galaxies like this one, similar in appearance to our own Milky Way, are yielding clues on how new stars are born.

THE INTERNATIONAL SCENE: FOCUS ON FORMER SOVIET UNION

Can the Former Soviet Union (FSU) make a smooth transition to market economics? And how should the transition take place? Answers are coming from research supported in part by NSF.

Observers of this region had feared a cultural bias there against capitalism. If so, the bias is quite weak. The researchers found that people in the FSU view capitalism in much the same way that U.S. citizens do. They see it as flawed yet superior to any other economic system. However, Americans do regard entrepreneurs far more favorably than do FSU citizens.

In another arena, while the FSU suffered the stresses of economic transition, scientific programs were starved for funds. NSF has provided crucial support for some of the most important programs, such as the Complex Seismological Expedition at Garm Tadjikistan, one of the most active earthquake zones in the FSU. The Foundation also has been actively involved in efforts to preserve environmental databases in the Former Soviet Union during the past year.

C H A P T E R   F O U R

TRANSFERRING KNOWLEDGE

Research such as that described in the previous chapter often leads to industrial and other applications that help make our nation more economically competitive. The importance of this knowledge transfer is reflected in the key role that industry plays in several NSF programs—among them Science and Technology Centers, Engineering Research Centers, and Industry/University Cooperative Research Centers. Through programs like these, industrial and academic researchers work together, often training university students on their projects.

One example of knowledge transfer and research applications comes from the Science & Technology Center for Microbial Ecology at Michigan State University. There cross-disciplinary research is contributing to the development of bacteria that can degrade toxic chemicals—such as wood preservatives, solvents, gasoline compounds, and dioxins—which threaten drinking water supplies and fish.

Cleansing the United States of polychlorinated biphenyls (PCBs) by conventional methods has been estimated to cost as much as $20 billion. However, such costs could be substantially reduced if microbes (bacteria, one-celled fungi, protozoans) can be discovered, or genetically engineered, and managed. Microbial detoxification is potentially one of the least expensive and most desirable detoxification methods for at least some sites.

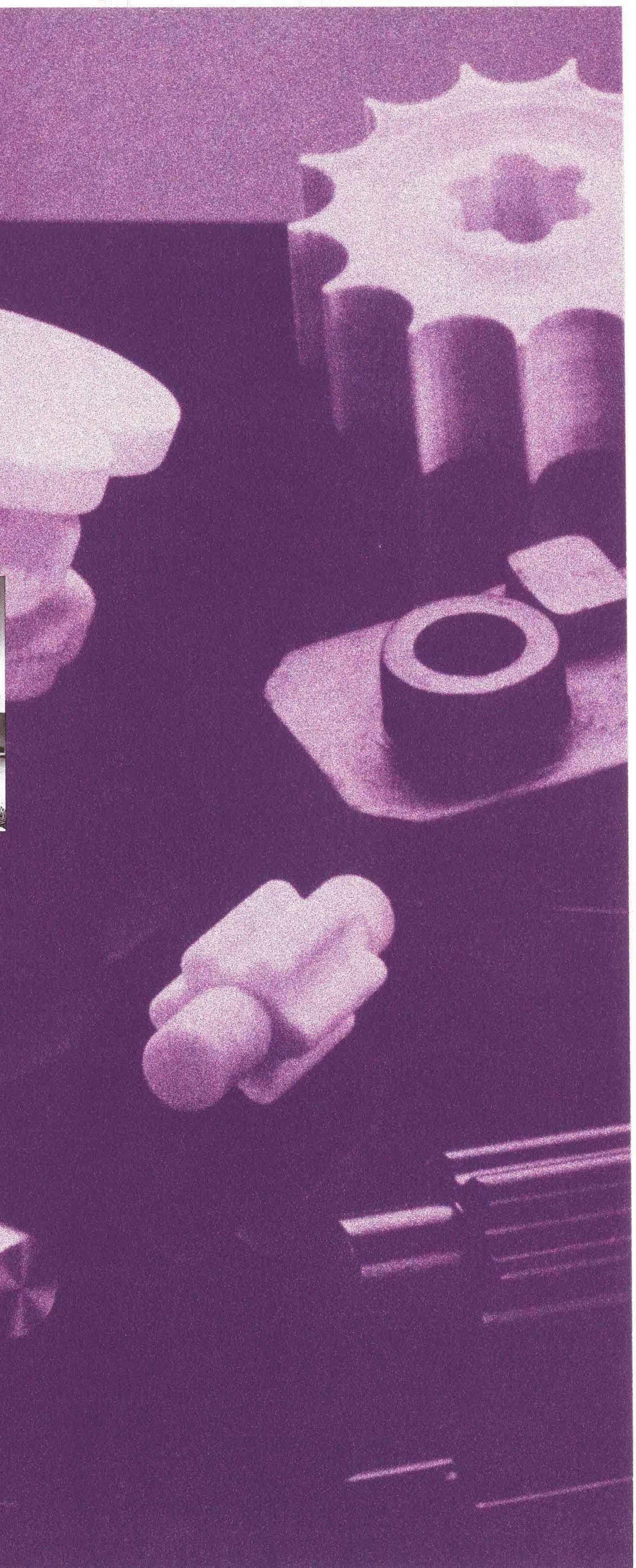
MATERIALS RESEARCH AND MANUFACTURING

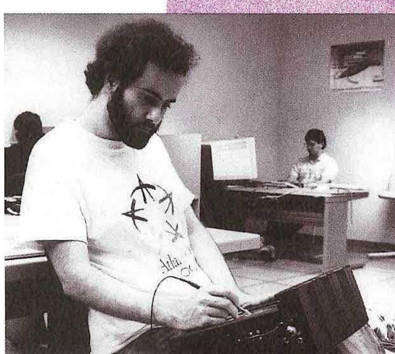
Another area that reflects knowledge transfer is the broad and complex endeavor of materials research. It encompasses everything from tree bark to advanced composites. The latter are used to make lighter, stronger, and more corrosion-resistant materials for such products as aircraft and bicycles.

Over the past few decades, basic research has played an increasingly important role in advancing the materials industry. The National Academy of Engineering has cited advances in materials science as among the top 10 engineering achievements of the last 25 years. Recent developments include the following:

- **Limited vision for the blind**. Researchers at the University of Utah in Salt Lake City have developed a three-dimensional electrode array, to be implanted in the visual cortex of blind people. This could form part of a system that might provide the blind with limited, visually guided mobility. Similar electrode arrays could be used in other parts of the nervous system, such as the

Mobile workers such as store clerks, inspectors, delivery personnel, and even some researchers may benefit from an "electronic notebook" developed by NSF-funded engineers.





Electronic notebook. Columbia University's Engineering Research Center for Telecommunications Research has collaborated with IBM on this project. A Ph.D. student is shown here with an experimental wireless notebook.

Since cognitive science is interdisciplinary, it must draw from fields that range from neurology to psychology to computers.

motor cortex of a quadriplegic, to generate command signals for controlling external devices such as an electric wheel chair.

- A crack detector for bridge decks and other concrete structures. A nondestructive evaluation instrument to detect flaws in concrete slabs and bridge decks has been developed by a NSF-funded scientist, and is being sold by German Instruments of Chicago and Denmark. The instrument can determine the size, type, and location of defects in concrete.

COGNITIVE SCIENCE: UNDERSTANDING INTELLIGENCE

For educators, understanding how human beings learn can foster new teaching strategies and technologies. In the industrial sector, cognitive science contributes to the development of intelligent manufacturing systems, which can help boost the U.S. competitive position in the world economy.

Since cognitive science is interdisciplinary, it must draw from fields that range from neurology to psychology to computers. To foster synergy among these disciplines, NSF has established a special center at the University of Pennsylvania. There engineers and computer scientists work with social and behavioral researchers on a range of problems. Among the early outcomes has been a statistical technique for discovering grammatical rules through analyses of texts. A linguist, psychologist, and computer scientist have been using the new technique to help them explore the way children acquire language.

Companies affiliated with this center, including AT&T Bell Laboratories of Holmdell, New Jersey, have been using these results in their efforts to improve computer communication systems that use natural language.

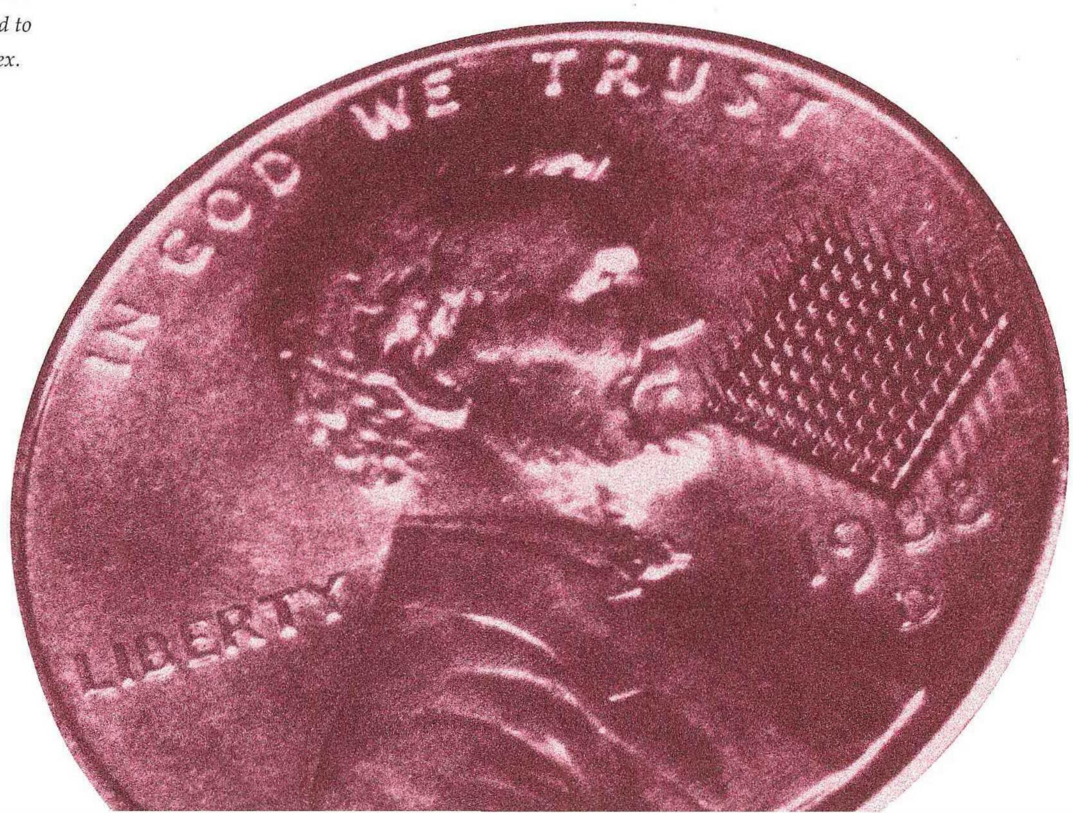
APPLICATIONS IN MATHEMATICS AND PHYSICS

In this information age, the large amounts of "input" we all receive become easier to manipulate and transform if they can be efficiently compressed. Researchers seeking more concise descriptions of mathematical structures have developed a mathematical method, called wavelets, that is now used in the rapid representation of signals with erratic patterns. Wavelets identify key features and compress the information content of pictures, graphics, and speech by about 80 percent. After transmission, this information is then reconstructed, again using wavelets, with extreme accuracy. Applications of this method are in engineering (reducing wind drag on vehicles); in medicine (streamlining medical imaging); and in the military (giving smart missiles, such as those used recently in Iraq, even more precise guidance systems).

In physics, a superconducting cyclotron for use in neutron cancer therapy has been successfully put into operation at Harper Hospital in Detroit. This venture resulted from collaboration between the staff of Michigan State University's National Superconducting Cyclotron Laboratory (NSCL), a nuclear physics research lab, and staff of the Harper Hospital Oncology Department. The goals of the project were to evaluate the biological effectiveness and clinical importance of neutron therapy, and to clarify the economic and operational advantages of a highly compact superconducting cyclotron. This facility, now in routine service at Harper, is used in the treatment of six patients per day, a figure expected to double in the near future.

Because of this project's success, a collaboration of the NSCL and several medical schools has been formed to develop a compact superconducting cyclotron for proton therapy—again a machine that would be practical in a clinical environment.

Visual system prosthesis. Enlargement shows a three-dimentional electrode array that is part of a visual aid and will be used to electrically stimulate the cortex.



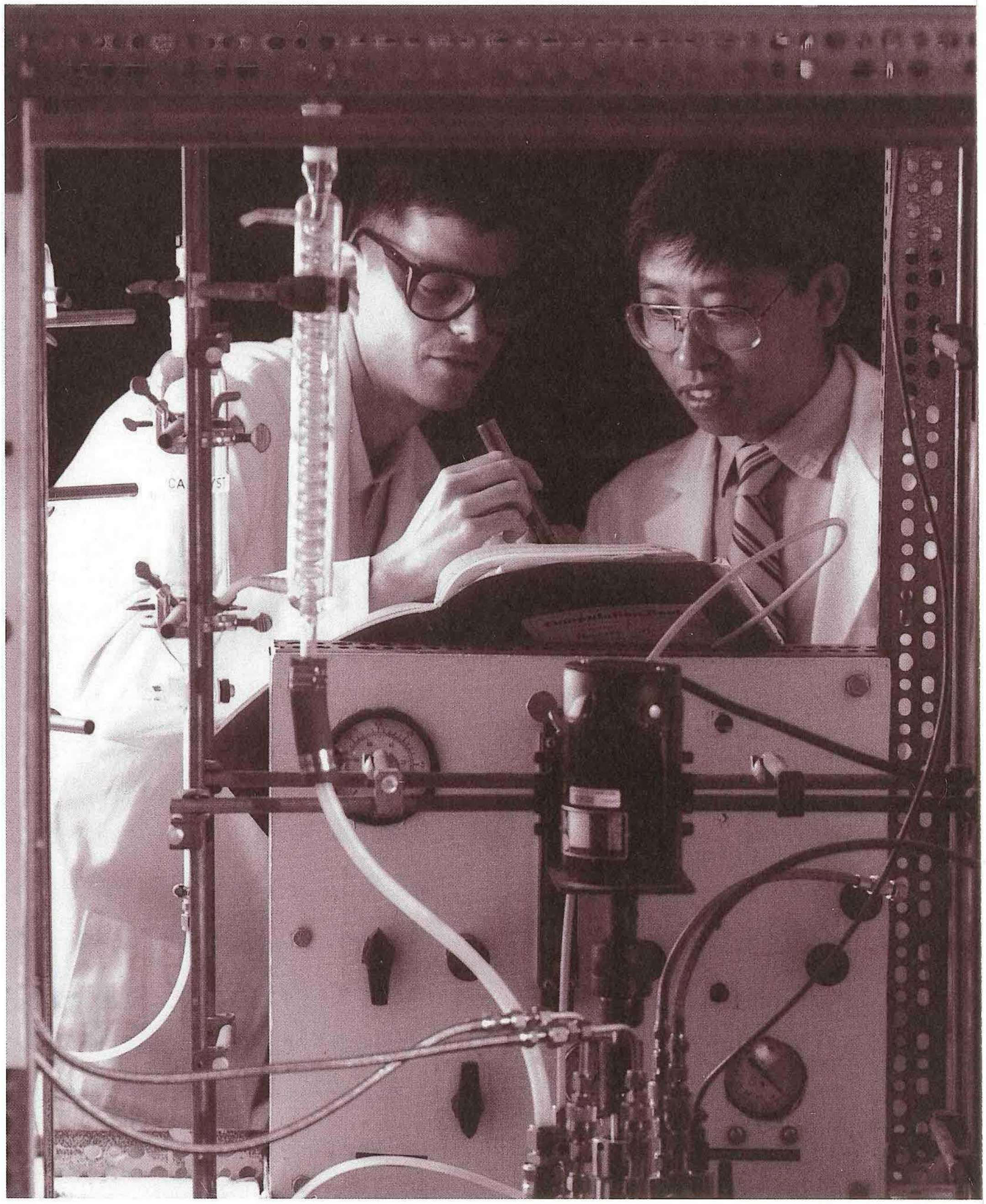
OTHER EXAMPLES OF KNOWLEDGE TRANSFER

- **"Acoustic" Air Conditioner: No CFCs.** The use of chlorofluorocarbons (CFCs) as refrigerants in air conditioning systems is one of many factors responsible for depletion of the ozone layer. Through an NSF Small Business Innovation Research grant, Continuum Dynamics, Inc. in Princeton, New Jersey, has been developing a novel system that eliminates CFC emission problems in air conditioning. The new system uses moving air and the sounds it produces as the "working fluid" (rather than a CFC or other synthetic refrigerant), thus lessening adverse effects on the environment.

  Said Alan Bilanin, President of Continuum Dynamics, "We anticipate that the efficiency and simplicity of the new device will make it a very attractive alternative to the vapor-compression air conditioning machines now being used in cars, residences, and office buildings."

- **Electronic "Notebook."** Portable lap-top computers have found only limited applications to date, largely among white-collar professionals who write or compute numbers aboard airplanes or trains or in hotel rooms while away from the office. There are several problems with lap-top computers, among them the need for a flat, steady surface in order to input data on the keyboard. Lap-tops are therefore not practical for use by the great majority of people who must collect information routinely and repeatedly throughout the day while moving around. They include technicians in industrial plants, store clerks, inspectors, police officials, delivery personnel, insurance agents, sales representatives, even some researchers. Most often, these workers collect information in handwriting on paper forms, later transferring it to an office computer.

  To offer these mobile workers a better way to collect information, NSF-funded engineers at Columbia University's Center for Telecommunication Research have developed an "electronic notebook." Access to distributed computing resources and databases using the electronic notebook is achieved via small, portable terminals that do not feature disks or keyboards.



Engineering Research Center work. Graduate student (left) works with chemical engineering professor at the University of Maryland's Systems Research Center. They are using a polymerization reactor.

ORGANIZATIONAL NEWS

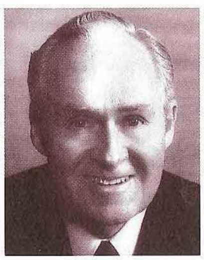
COMMISSION ON NSF's FUTURE

In August 1992, the National Science Board (NSB)—the 24-member policy making arm of the National Science Foundation—established a Commission on the Future of the National Science Foundation.

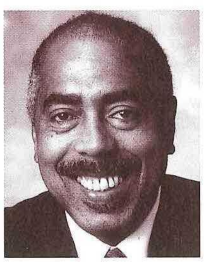
Proposed by the NSF Director in the context of a long-range planning process underway at NSF (see following), the Commission examined how NSF should adapt to changes on a national and global scale that affect the agency's mission. The 15-member commission looked at ways for NSF to enhance its unique role as the major supporter of fundamental research and education, while assuming greater responsibility for developing links between academic science and industry. The group also explored new directions for the Foundation in fostering connections between research and technology that would be beneficial to the nation.

In addition, the Commission examined the specific role of NSF in making the results of research more accessible in efforts to build America's technology base.

William H. Danforth
Co-chairman



Robert W. Galvin
Co-chairman



Walter E. Massey
Director of the National Science Foundation

James J. Duderstadt
Chairman of the National Science Board

CO-CHAIRMEN:

William H. Danforth, Chancellor, Washington University, St. Louis

Robert W. Galvin, Chairman, Executive Committee, Motorola

MEMBERS:

John A. Armstrong, Vice President for Science and Technology, IBM

Jacqueline Barton, Professor, California Institute of Technology

Lindy Boggs, former U.S. Representative, New Orleans, Louisiana

Lewis M. Branscomb, Albert Pratt Professor of Public Service, Harvard University

Peter Eisenberger, Director, Princeton Materials Institute

***Marye Anne Fox**, M. June and J. Virgil Waggoner Regents Chair in Chemistry, University of Texas at Austin

C. Peter Magrath, President, National Association of State Universities and Land-Grant Colleges

Percy A. Pierre, Vice President of Research and Graduate Studies, Michigan State University

***Frank H.T. Rhodes**, President, Cornell University

Earl Richardson, President, Morgan State University

***Ian M. Ross**, President Emeritus, AT&T Bell Labs

William J. Rutter, Chairman of the Board, Chiron Corporation

Donna Shalala, Chancellor, University of Wisconsin—Madison

Charles N. Brownstein, Executive Secretary

*members of the National Science Board

The NSF serves as a major source of new scientific and engineering ideas and skilled people underpinning broad sectors of our economy and our society.

Changes in American businesses and universities hold promise of a more receptive adoption and practical application of the knowledge born of research and advanced education.

NSF should have two goals . . . One is to support first-rate research at many points on the frontiers of knowledge, identified and defined by the best researchers. The second goal is a balanced allocation of resources in strategic research areas.

Nature knows nothing about disciplinary boundaries.

Undergraduate education is enriched by faculty participating in research.

The great strength of American science and of American universities is the absence of rigid cultural barriers between science and engineering and between pure research and its applications.

The Board and the National Science Foundation are today the lead organizations representing the interests of broad science and engineering in the United States.

STRATEGIC PLAN

NSF also drew up a long range strategic plan to help meet national needs for research support in the 1990s and beyond. The plan includes:

- Intellectual integration, to deal with the growing complexity and interdisciplinary nature of fundamental research;
- Organizational integration, stressing partnerships to extend intellectual and financial resources and to speed progress in discovery and use of knowledge;
- Investment in people, the most important resources in scientific and technological research;
- Keeping NSF a proactive organization, a vital national source of support for research and education; and
- Accountability as a critical component of the stewardship expected of NSF and required to achieve its goals.

A further new priority of NSF is to build stronger bridges between academia and industry, so that American academic institutions can contribute their expertise to improving the standard of living in the United States and our ability to compete internationally.

NSF SENIOR STAFF AND NATIONAL SCIENCE BOARD MEMBERS (FY 1992)

NATIONAL SCIENCE FOUNDATION SENIOR STAFF (As of September 30, 1992)*

Director, Walter E. Massey

Deputy Director, Frederick M. Bernthal

General Counsel, Charles H. Herz

Director, Office of Equal Opportunity Programs, Eugene H. Cota-Robles

Director, Office of Legislative and Public Affairs, Raymond E. Bye, Jr.

Director, Office of Planning and Assessment, Charles N. Brownstein

Director, Office of Science and Technology Infrastructure, Nathaniel Pitts

Assistant Director for Biological Sciences, Mary E. Clutter

Assistant Director for Computer and Information Science and Engineering, Nico A. Habermann

Assistant Director for Education and Human Resources, Luther S. Williams

Assistant Director for Engineering, Joseph Bordogna

Assistant Director for Geosciences, Robert W. Corell

Assistant Director for Mathematical and Physical Sciences, William C. Harris

Assistant Director for Social, Behavioral and Economic Sciences, Cora B. Marrett

Director, Office of Budget, Finance and Award Management, Joseph L. Kull

Director, Office of Information and Resource Management, Constance K. McLindon

**NSF was reorganized in the early part of fiscal 1992. That reorganization affected several of the offices listed above.*

NATIONAL SCIENCE BOARD (As of September 30, 1992)

TERMS EXPIRE MAY 10, 1994

WARREN J. BAKER
President
California Polytechnic State University
San Luis Obispo, CA

ARDEN L. BEMENT, JR.
Vice President, Science and Technology
TRW, Inc.
Cleveland, OH

W. GLENN CAMPBELL
Counselor, Hoover Institution
Stanford University
Stanford, CA

DANIEL C. DRUCKER
Graduate Research Professor, Department of Aerospace Engineering
Mechanics and Engineering Science
University of Florida
Gainesville, FL

CHARLES L. HOSLER
Senior Vice President for Research and Dean of Graduate School
and Professor of Meteorology-Emeritus, Department of Meteorology
Pennsylvania State University
University Park, PA

TERMS EXPIRE MAY 10, 1998

F. ALBERT COTTON
W.T. Doherty-Welch Foundation
Distinguished Professor of Chemistry
and Director
Laboratory for Molecular Structure
and Bonding
Texas A&M University
College Station, TX

CHARLES E. HESS
Professor and Director of International
Programs
Department of Environmental
Horticulture
University of California
Davis, CA

JOHN E. HOPCROFT
Associate Dean for College Affairs
College of Engineering
Cornell University
Ithaca, NY

JAMES L. POWELL
Chief Executive Officer
The Franklin Institute
Philadelphia, PA

FRANK H.T. RHODES
President
Cornell University
Ithaca, NY

IAN M. ROSS
President-Emeritus
AT&T Bell Laboratories, Inc.
Holmdel, NJ

RICHARD N. ZARE
Marguerite Blake Wilbur Professor
Department of Chemistry
Stanford University
Stanford, CA

(One vacancy as of September 30, 1992)

MEMBER EX OFFICIO

WALTER E. MASSEY
(Chairman, Executive Committee)
Director
National Science Foundation
Washington, DC

MARTA CEHELSKY
Executive Officer, National Science
Board
National Science Foundation
Washington, DC

LINDA G. SUNDRO
Inspector General
National Science Foundation
Washington, DC

PATENTS AND FINANCIAL TABLES FOR FISCAL YEAR 1992

Patents and Inventions Resulting from NSF Support:

During fiscal year 1992, the Foundation received 287 invention disclosures. Allocations of rights to 148 of those inventions were made by September 30, 1991. These resulted in dedication to the public through publication in 22 cases, retention of principal patent rights by the grantee or inventor in 115 instances, and transfer to other Government agencies in 11 cases. Licenses were received by the Foundation in 44 patent applications filed by grantees and contractors who retained principal rights in their inventions.

TABLE ONE - BIOLOGICAL SCIENCES

	Number of Awards	Amount (in Millions)
Molecular and Cellular Biosciences	1,049	$ 83.13
Integrative Biology and Neurosciences	1,113	77.19
Environmental Biology	878	72.64
Biological Instrumentation and Resources	235	41.39
Total	3,275	$ 274.35

SOURCE: Fiscal Year 1994 Justification of Estimates of Appropriation to the Congress.

TABLE TWO - COMPUTER AND INFORMATION SCIENCE AND ENGINEERING

	Number of Awards	Amount (in Millions)
Computer and Computation Research	428	$ 34.77
Information, Robotics and Intelligent Systems	377	26.90
Microelectronic Information Processing Systems	244	21.44
Advanced Scientific Computing	91	69.43
Networking and Communications Research and Infrastructure	235	35.38
Cross-Disciplinary Activities	167	22.45
Total	1,542	$ 210.37

TABLE THREE - ENGINEERING

	Number of Awards	Amount (in Millions)
Biological and Critical Systems	530	$ 39.38
Chemical and Thermal Systems	517	36.30
Design and Manufacturing Systems	374	22.52
Electrical and Communications Systems	502	35.12
Engineering Education and Centers	282	75.42
Industrial Innovation Interface	281	24.16
Mechanical and Structural Systems	443	25.20
Total	2,929	$ 258.10

TABLE FOUR - GEOSCIENCES

	Number of Awards	Amount (in Millions)
Atmospheric Sciences	751	$ 126.50
Earth Sciences	918	75.90
Ocean Sciences	994	177.50
Science & Technology Centers	1	.93
Total	2,664	$ 380.83

TABLE FIVE - MATHEMATICAL AND PHYSICAL SCIENCES

	Number of Awards	Amount (in Millions)
Mathematical Sciences	1,415	$ 78.42
Astronomical Sciences	375	112.22
Physics	736	138.07
Chemistry	1,393	112.11
Materials Research	1,099	143.54
Major Research Equipment	3	37.97
Total	5,021	$ 622.33

TABLE SIX - SOCIAL, BEHAVIORAL AND ECONOMIC SCIENCES

	Number of Awards	Amount (in Millions)
Social, Behavioral and Economic Sciences	1,179	$ 65.99
International Cooperative Scientific Activities	488	13.11
Science Resources Studies	33	6.89
Total	1,700	$ 85.99

TABLE SEVEN - EDUCATION AND HUMAN RESOURCES

	Number of Awards	Amount (in Millions)
Systemic Reform	89	$ 44.49
Elementary, Secondary and Informal Education	837	198.12
Undergraduate Education	919	60.66
Graduate Education and Research Development	255	55.60
Human Resource Development	200	46.28
Research, Evaluation and Dissemination	120	36.26
Total	2,420	$ 441.41

TABLE EIGHT - UNITED STATES POLAR RESEARCH PROGRAM

NOTE: In FY 1992 and FY 1993 the Arctic Program was funded through the Research and Related Appropriation. In Fiscal Year 1994, the Arctic Research Program will be funded by the U.S. Polar Research appropriation.

	Number of Awards	Amount (in Millions)
U.S. Antarctic Research Program	215	$ 22.00
Operations and Science Support	35	55.37
U.S. Antarctic Logistical Support	1	10.00
Subtotal	251	87.37
U.S. Arctic Research Program	206	21.13
Total	457	$ 108.50

TABLE NINE - ACADEMIC RESEARCH FACILITIES AND INFRASTRUCTURE

	Number of Awards	Amount (in Millions)
Academic Research Facilities and Infrastructure	91	$ 33.36
Total	91	$ 33.36

TABLE TEN - EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH

NOTE: In FY 1992 EPSCoR was funded through the Research and Related Activities appropriation. In FY 1993 and FY 1994 EPSCoR will be funded by the Education and Human Resources activity.

	Number of Awards	Amount (in Millions)
Experimental Program to Stimulate Competitive Research (EPSCoR)	29	$ 18.02
Total	29	$ 18.02

About the National Science Foundation (flyer)
NSF Bulletin (published monthly except in July and August)
Publications of the National Science Foundation (list)
Grants for Research and Education in Science and Engineering (how to apply)
Guide to Programs (catalog)
NSF Films (booklet)
NSF Directions (newsletter)

Single copies of these publications are available from Forms and Publications, NSF, 1800 G Street, N.W., Washington, D.C. 20550, (202) 357-7861.

Effective October 25, 1993, the new mailing address will be:

National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230

If you are a user of electronic mail and have access to either BITNET or Internet, you may prefer to order publications electronically. BITNET users should address requests to pubs@nsf. Internet users should send requests to pubs@nsf.gov. In your request, include the NSF publication number and title, number of copies, your name, and a complete mailing address. Publications will be mailed within 2 days of receipt of request.

Electronic Dissemination

You can get fast information about all NSF programs through STIS (Science and Technology Information System), NSF's online publishing system, described in NSF 91-10 (rev. 10/25/92), the "STIS flyer."

To get a paper copy of the flyer, call the NSF Publications Section at 202-357-7861. For an electronic copy, send an E-mail message to stisfly@nsf.gov (Internet) or STISFLY@NSF (BITNET).

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

NSF 93-1