# NSF GUIDE TO PROGRAMS, FISCAL YEAR 2002

NSF 02-03

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# INTRODUCTION

**About the National Science Foundation**

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-75). The Act states that NSF shall consist of the National Science Board (NSB) and the Director and establishes NSF to, among other purposes, "promote the progress of science" and "advance the national health, prosperity, and welfare." The NSB establishes NSF's policies within the framework of applicable national policies as set forth by the President and Congress and, together with the Director, recommends and encourages the pursuit of national policies for the promotion of research and education in science and engineering.

From its 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. NSF is also committed to ensuring the Nation's supply of scientists, engineers, and science and engineering educators.

NSF funds research and education in most fields of science and engineering. It does this through grants to and cooperative agreements with more than 2,000 colleges, universities, K–12 school systems, businesses, informal science organizations, and other research institutions throughout the United States. NSF accounts for about one-fourth of all Federal support to academic institutions for basic research.

NSF receives approximately 30,000 proposals each year for research, education, and training projects, of which approximately 10,000 are funded. In addition, it receives several thousand applications for graduate and postdoctoral fellowships. NSF grants are typically awarded to universities, colleges, academic consortia, nonprofit institutions, and small businesses. NSF operates no laboratories itself, but it does support National Research Centers, user facilities, certain oceanographic vessels, and Antarctic research stations. It also supports cooperative research between universities and industry, U.S. participation in international scientific efforts, and educational activities at every academic level.

NSF is structured much like a university, with grants-funding divisions for the various disciplines and fields of science and engineering, and for science, mathematics, engineering, and technology education. NSF also uses a variety of management mechanisms to coordinate research in areas that cross traditional disciplinary boundaries. NSF is helped by advisers from the scientific community who serve on formal committees or as ad hoc reviewers of proposals. This advisory system, which focuses on both program directions and specific proposals, involves approximately 50,000 scientists and engineers each year. NSF staff members who are experts in a certain field or area make award

recommendations; proposers get unattributed verbatim copies of peer reviews.

Grantees are wholly responsible for conducting their project activities and preparing the results for publication. Thus, NSF does not assume responsibility for such findings or their interpretation.

NSF welcomes proposals on behalf of all qualified scientists, engineers, and educators. It strongly encourages women, minorities, and persons with disabilities to participate fully in its programs. In accordance with Federal statutes and regulations and with NSF policies, no person on grounds of race, color, age, sex, national origin, or disability will be excluded from participation in any program or activity receiving financial assistance from NSF, or be denied the benefits of such a program or activity, or be subjected to discrimination under any such program or activity, although some programs may have special requirements that limit eligibility.

Facilitation Awards for Scientists and Engineers with Disabilities provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects.

NSF has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment, or general information. TDD may be accessed at 703-292-5090; FIRS at 1-800-877-8339.

## Deadlines and Target Dates

Many of the programs listed in this *Guide to Programs* have an established deadline or target date for the submission of proposals. Information about most of these dates can be found in the NSF E-Bulletin, an electronic publication available at http://www.nsf.gov/home/ebulletin/. Individual program announcements and solicitations also carry deadline and target date information, as do NSF Division web sites.

A list of all deadlines sorted by date and by program area is available at http://www.nsf.gov/home/deadline/deadline.htm.

## Eligibility Requirements

Except where a program solicitation establishes more restrictive eligibility criteria, individuals and organizations in the following categories may submit proposals to NSF:

- **Universities and Colleges—**U.S. universities and 2- and 4-year colleges (including community colleges) acting on behalf of their faculty members.

- **Nonprofit, Nonacademic Organizations—**Independent museums, observatories, research laboratories, professional societies, and similar organizations in the United States that are directly associated with education or research activities.

- **For-Profit Organizations—**U.S. commercial organizations, especially small businesses with strong capabilities in scientific or engineering research and education. An unsolicited proposal from a commercial organization may be funded in cases where the project is of special concern from a national point of view; where special resources are available for the work; or where the proposed project is especially meritorious. NSF is interested in supporting projects that couple industrial research resources and perspectives with those of universities; therefore, it especially welcomes proposals for cooperative projects involving both universities and the private commercial sector.

- **State and Local Governments—**State educational offices or organizations and local school districts may submit proposals intended to broaden the impact, accelerate the pace, and increase the effectiveness of improvements in science, mathematics, and engineering education at K–12 and postsecondary levels.

- **Unaffiliated Individuals—**Scientists, engineers, and educators in the United States and U.S. citizens may be eligible for support, provided that the individual is not employed by or affiliated with an organization, and

  –the proposed project is sufficiently meritorious and otherwise complies with the conditions of any applicable proposal-generating document;

  –the proposer has demonstrated the capability and has access to any necessary facilities to carry out the project; and

  –the proposer agrees to fiscal arrangements that, in the opinion of the NSF Grants Office, ensure responsible management of Federal funds.

Unaffiliated individuals should contact the appropriate program before they prepare a proposal for submission.

- **Foreign Organizations—**NSF rarely provides support to foreign organizations. NSF will consider proposals for cooperative projects involving U.S. and foreign organizations, provided support is requested only for the U.S. portion of the collaborative effort.

- **Other Federal Agencies—**NSF does not normally support research or education activities by scientists, engineers, or educators employed by Federal agencies or Federally Funded Research and Development Centers (FFRDC's). However, a scientist, engineer, or educator who has a joint appointment with a university and a Federal agency (such as a Veterans Administration Hospital) or with a university and an FFRDC may submit proposals through the university and may receive support if he or she is a bona fide faculty member of the university, although part of the salary may be provided by the Federal agency. In some unusual circumstances, other Federal agencies and FFRDC's may submit proposals directly to NSF. Preliminary inquiry should be made to the appropriate program before a proposal is prepared for submission.

To check on special requirements for a specific program, consult the applicable program solicitation or contact the program directly.

**Who May Submit Proposals**

Scientists, engineers, and educators usually initiate proposals that are officially submitted by their employing organization. It is recommended that the proposal be discussed with appropriate NSF program staff before formal submission.

Graduate students are not encouraged to submit research proposals, but they can arrange to serve as research assistants to faculty members. Some NSF divisions accept proposals for Doctoral Dissertation Research Grants, which should be submitted by a faculty member or thesis adviser on behalf of the graduate student. NSF also provides support specifically for women and minority scientists and engineers, scientists and engineers with disabilities, and faculty at primarily undergraduate academic institutions.

**Merit Review Criteria for the Selection of Research and Education Projects**

Funding decisions on proposals are made largely through the process of merit review, in which expert evaluation by external peer

reviewers contributes to recommendations by NSF program managers. NSF receives more than 170,000 external reviews each year from approximately 50,000 scientists and engineers.

The NSB approved revised criteria for evaluating proposals at its meeting on March 28, 1997 (NSB 97-72). The criteria are designed to be useful and relevant across NSF's many different programs, but NSF will employ special criteria as required to highlight the specific objectives of certain programs and activities.

On September 20, 1999, the NSF Director issued Important Notice 125, Subject: Merit Review Criteria. The Important Notice reminds proposers and reviewers of the importance of ensuring that the merit review criterion relating to broader impacts is considered and addressed in the preparation and review of proposals submitted to NSF. It also indicates NSF's intent to continue to strengthen its internal processes to ensure that both of the merit review criteria are viewed as suggestions and that not all of the considerations involved in evaluating each criterion will apply to any given proposal.

The two merit review criteria are listed below. Following each criterion are considerations that reviewers may employ in their evaluation. These considerations are suggestions, and not all will apply to any given proposal. While reviewers are expected to address both of the merit review criteria, reviewers will be asked to address only those considerations that are relevant to the proposal they are reviewing and for which they are qualified to make judgments.

**What is the intellectual merit of the proposed activity?** How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of prior work.) To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

**What are the broader impacts of the proposed activity?** How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?

Principal investigators should address the following elements in their proposal, to provide reviewers with the information necessary to respond fully to both of the NSF merit review criteria. NSF staff will give these elements careful consideration in making funding decisions.

**Integration of Research and Education.** One of the principal strategies in support of NSF's goals is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions provide abundant opportunities in which individuals may concurrently assume responsibilities as researchers, educators, and students and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the diversity of learner perspectives.

**Integrating Diversity Into NSF Programs, Projects, and Activities.** Broadening opportunities and enabling the participation of all citizens—women and men, underrepresented minorities, and persons with disabilities—is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

## ⓘ For More Information

The *Grant Proposal Guide (GPG)* provides guidance for the preparation and submission of proposals to NSF. The latest edition is available at http://www.nsf.gov/cgi-bin/getpub?gpg. Some NSF programs have program solicitations that modify the general provisions in the *GPG*. In such cases, the guidelines provided in the solicitation must be followed. Contact with NSF program personnel before a proposal is prepared is encouraged.

Effective October 1, 2000, all proposals to NSF must be submitted electronically via the NSF FastLane system (http://www.fastlane.nsf.gov/fastlane.htm). The *GPG* includes instructions on how to obtain an exception to the FastLane requirement for those who have difficulties with submission or cannot submit electronically to NSF.

### Press Releases and Other Media Materials

As research results develop, NSF grantees should consider whether or not they might warrant National press interest. If so, the grantee should contact either the Media Section in NSF's Office of Legislative and Public Affairs, or the public affairs office of their home institution, to discuss the possibility of media coverage. Contact should be made far enough in advance of a formal announcement to allow sufficient time to develop an appropriate press strategy. Such a strategy may include a press release or news tip, video news release, press conference or briefing, or editorial (opinion) pieces. If unsure of the newsworthiness, contact NSF or the institution public affairs office. National media interviews should be granted only after advance coordination with a public affairs officer. The NSF Media Section can be reached at (703) 292-8070.

# GENERAL INFORMATION

## How to Use This Guide

The *Guide to Programs* is a compilation of funding opportunities offered by the National Science Foundation (NSF) for research and education in science, mathematics, engineering, and technology. The *Guide* includes broad, general descriptions of programs and activities for each NSF Directorate, as well as sources for more information. It also offers links to other information sources, including NSF Directorate home pages; to related publications such as program announcements and solicitations that contain additional proposal or eligibility information; and to the E-Bulletin for deadline and target date information.

## E-Bulletin

The NSF E-Bulletin is a web-based document that announces current deadline and target dates for the submission of proposals to the Foundation. The E-Bulletin is updated daily on the NSF web site. Subscribers to NSF's Custom News Service (CNS) can receive, via email, a monthly edition of the E-Bulletin (see information on CNS below). Each edition covers a 4-month period that includes the current month and the following 3 months. A search form in the E-Bulletin lets you find deadlines and target dates for a selected period of time for each research area. For individuals who do not have web access, a print-on-demand monthly edition is available. The E-Bulletin can be accessed at http://www.nsf.gov/home/ebulletin/.

## How to Obtain NSF Publications

NSF strongly encourages electronic dissemination of its documents and offers several ways of obtaining publications electronically.

- **Online Document System (ODS)—** Includes all forms and publications available electronically from NSF. The ODS lets you browse through NSF's electronic publications catalogue and offers a search capability that lets you search by document type, publication title, publication number, and keyword. The ODS home page is located at http://www.nsf.gov/cgi-bin/pubsys/browser/odbrowse.pl. For a list of all current NSF documents available in electronic format, visit the ODS Index at http://www.nsf.gov/pubsys/index.htm.

- **Custom News Service (CNS)—**An e-mail and web-based alert service designed to allow quick and easy access to NSF news, publications, and information. CNS lets users create a personal profile in which they choose the types of information they are interested in, and notifies them via e-mail when new documents matching their profile are added to NSF's Online Document System. E-mails include links to the electronic location of each document and/or full text of short documents. A weekly e-mail alert listing all documents added the previous week is available under "Notification Options" when you set up or modify your profile.

To sign up for NSF's Custom News Service, visit http://www.nsf.gov/home/cns/. *(Note: You must have an established Internet e-mail address to use CNS.)*

- **Other Methods—**NSF also makes its publications available to users without web access. For information on other methods of obtaining NSF publications, see http://www.nsf.gov/pubs/start.htm, or call the NSF Information Center at 703-292-5111 (TDD: 703-292-5090; e-mail: info@nsf.gov).

# NSF CROSSCUTTING INVESTMENT STRATEGIES

This section contains a partial listing of cross-directorate programs sponsored by the National Science Foundation (NSF). Activities not mentioned here may appear elsewhere in this publication. Refer to the appropriate directorate.

- **NSF Priority Multidisciplinary Areas**
- **Human Resource and Career Development**
- **Crosscutting Research, Instrumentation, and Partnering Programs**

### ⓘ For More Information

Visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm.

# NSF PRIORITY MULTIDISCIPLINARY AREAS

The National Science Foundation's (NSF) investments in priority areas reach across science and engineering and bring new knowledge to bear on areas of great national interest. NSF works with other Government agencies to identify and support these priority multidisciplinary areas. The goal is to accelerate scientific and technical progress by identifying and addressing gaps in knowledge and barriers that prevent progress.

The priority multidisciplinary areas that NSF has selected for increased attention during the next several years are

1. **Biocomplexity in the Environment**
2. **Information Technology Research**
3. **Learning for the 21st Century**
4. **Nanoscale Science and Engineering**

The priority multidisciplinary areas in this section address NSF's three strategic goals:

**1. People –** A diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens.

**2. Ideas –** Discovery at and across the frontier of science and engineering, and connections to its use in the service of society.

**3. Tools –** Broadly accessible, state-of-the-art, and shared research and education tools.

## 1. Biocomplexity in the Environment

The environment is a subject of profound national importance and scientific interest, making it a strategic priority for NSF. The goals of the Foundation's increasing investment in this area include enhancement of fundamental environmental research in all relevant disciplines and in interdisciplinary and long-term research; creation of educational opportunities that build scientific and technological capacity; discovery of innovative methods that avoid environmental harm and inform the decisionmaking process; and support for advanced physical, technological, informational, and international infrastructure.

A centerpiece of NSF's Environmental Research and Education portfolio is the Biocomplexity in the Environment (BE) competition. Initiated in fiscal year 1999, this special competition promotes comprehensive, integrated investigations of environmental systems using advanced scientific and engineering methods.

Biocomplexity refers to the dynamic web of often surprising interrelationships that arise when components of the global ecosystem—biological, physical, chemical, and the human dimension—interact. Investigations of biocomplexity in the environment are intended to provide a more complete understanding in the areas of natural processes; human behaviors and decisions in the natural world; and ways to use new technology effectively to observe the environment and sustain the diversity of life on Earth.

By placing biocomplexity studies in an environmental context, this competition emphasizes research with the following characteristics: strong interdisciplinary nature; focus on complex environmental systems, including interactions of nonhuman biota and humans; and focus on systems with high potential for exhibiting nonlinear or highly coupled behavior with other systems.

Beginning with the fiscal year 2001 competition, and planned for the fiscal year 2002 competition as well, four

interdisciplinary areas are being emphasized:

- Dynamics of Coupled Natural and Human (CNH) Systems—Emphasizes quantitative understanding of short- and long-term dynamics of natural capital. Also emphasized are how humans value and influence ecosystem services and natural resources, including consideration of landscapes and land use; and the influence of uncertainty, resilience, and vulnerability in complex environmental systems on societal institutions.

- Coupled Biogeochemical Cycles (CBC)—Focuses on the interrelation of biological, geochemical, geological, and physical processes at all temporal and spatial scales, with particular emphasis on understanding linkages between cycles and the influence of human and other biotic factors on those cycles.

- Genome-Enabled Environmental Science and Engineering (GEN-EN)—Encourages the use of genetic information to understand ecosystem functioning and the adaptation of organisms to ecological roles.

- Instrumentation Development for Environmental Activities (IDEA)—Supports the development of instrumentation and software that relies on and uses microelectronics, photonics, telemetry, robotics, sensing systems, modeling, data mining, and analysis techniques to bring recent laboratory instrumentation advances to bear on the full spectrum of environmental biocomplexity questions.

- Materials Use: Science, Engineering, and Society (MUSES)—Supports projects that study the reduction of adverse human impact on the total interactive system of resource use, and the design and synthesis of new materials with environmentally benign impacts on biocomplex systems, as well as maximizing the efficient use of individual materials throughout their life cycles.

**For More Information**

See program announcement NSF 01-34 (or its successor); or visit the NSF Environmental Research and Education web site, http://www.nsf.gov/ere. Additional information on anticipated multidisciplinary BE activities in materials-use science and engineering; environmental informatics; social adaptation to hazards; and molecular scale and genomic studies of subsurface processes will be posted on the web site.

**2. Information Technology Research (ITR)**

Sustained leadership in the United States in information technology requires an aggressive Federal program to create new knowledge in a variety of areas. The U.S. economy's robust growth has in part resulted from new ideas that became the basis for new products. For example, NSF contributed greatly to the development of today's Internet. NSF's investments—in ideas, people, and tools—have benefited greatly from the application of information technology.

NSF faces two major challenges and opportunities with respect to information technology. The first challenge is to support the people, ideas, and tools that will create and advance knowledge in all areas of information science and engineering. Wholly new computational approaches are needed for problems arising from the science and engineering disciplines and the development of new learning technologies for use in education.

The second challenge is to upgrade the computational and computing infrastructures for all fields that NSF supports. Researchers and educators in many areas need to incorporate information technology and, in some cases, revolutionize their experimental

and collaborative processes to attain new effectiveness and greater efficiency. Also, the United States must address a range of access and workforce issues. Overcoming inequities will require innovative educational technologies such as highly interactive computer science courseware that is both multicultural and multimedia.

NSF is the lead agency for a multiagency 5-year research initiative in information technology. Each agency participating in the initiative will define specific programs in keeping with that agency's mission. NSF is primarily responsible for basic research to advance knowledge, and for education and workforce development activities. The multiyear Information Technology Research investment by NSF will lead to the following outcomes:

- Advancement of fundamental knowledge in techniques for computation, the representation of information, the manipulation and visualization of information, and the transmission and communication of information.

- Enhanced knowledge about how to design, build, and maintain large, complex software systems that are reliable, predictable, secure, and scalable.

- New knowledge about distributed and networked systems and interactions among component parts, as well as the interaction of systems with both individuals and cooperating groups of users. Such networks can empower a broadly distributed scientific community to participate fully in frontline research.

- Development of a significantly advanced high-end computing capability needed to solve myriad important science and engineering problems.

- Increased understanding of the societal, ethical, and workforce implications of the information revolution.

- A strong information technology workforce and a citizenry capable of using information technology effectively.

**ⓘ For More Information**

See program announcement NSF 01-149; or visit the ITR web site at http://www.itr.nsf.gov/.

### 3. Learning in the 21st Century

Leadership in the United States in the concept-based, innovation-led global economy of the next century will depend on the success of building and sustaining a competent and diverse scientific, mathematics, engineering, and technology (SMET) workforce, drawing on all elements of the Nation's rich human resources.

The SMET education continuum extends from preK through elementary and secondary, to undergraduate, graduate, and continuing professional education. The level, quality, and accessibility of SMET education depend on the following: understanding the nature of learning; strategically enabling an improved science- and technology-based educational enterprise; and building an infrastructure to broaden participation of all members of our society.

Across the NSF, organizations provide disciplinary and interdisciplinary support to integrate research and education, as well as new tools and models for K–12, undergraduate, and graduate education. These activities will recognize the importance of the SMET content of educational programs for K–12 students and for the instructional workforce.

A National Digital Library for SMET education will provide ready access to the highest quality education materials, pedagogy, and research on learning, and will enhance the quality of graduate,

undergraduate, K–12, and public science education.

The outcome of NSF's sustained investment in research, education, training, and human resource programs will be

- enhanced knowledge about how humans learn;
- enhanced practices throughout the SMET education enterprise—especially at the K–12 level—leading to improved teacher performance and student achievement; and
- a more inclusive and globally engaged SMET enterprise that fully reflects the strength of America's diverse population.

### 4. Nanoscale Science and Engineering

Nanoscale science and engineering promises to produce a dominant technology for the 21st century. Control of matter at the nanoscale level underpins innovation in critical areas, from information and medicine to manufacturing and the environment.

One nanometer (one billionth of a meter) is a magical point on the dimensional scale. Nanostructures are at the confluence of the smallest of human-made devices and the largest molecules of living systems. Biological cells such as red blood cells have diameters in the range of thousands of nanometers. Microelectromechanical systems are now approaching this same scale. This means we are now at the point of connecting machines to individual cells.

Twelve Federal agencies have joined together to promote advances in nanotechnology, in which NSF has the largest investment. NSF's nanoscale science and engineering program is a multiyear investment whose goals include the following:

- discovery of novel phenomena, processes, and tools;
- enhanced methods for the synthesis and processing of engineered, nanometer-scale building blocks for materials and system components;
- new device concepts and system architecture appropriate to the unique features and demands of nanoscale engineering;
- development of a new generation of skilled workers who have the multidisciplinary perspective necessary for rapid progress in nanotechnology; and
- increased understanding of societal, ethical, and workforce implications of nanoscience and nanotechnology.

**For More Information**

See the latest program solicitation, available on the nano program web site, http://www.nsf.gov/nano/.

## HUMAN RESOURCE AND CAREER DEVELOPMENT

Among NSF's crosscutting investments are programs directed to the development of a diverse, internationally competitive, and globally engaged workforce of scientists, engineers, and well-prepared citizens. This section of the Guide highlights programs for human resource and career development that are supported as NSF-wide, as well as specific crosscutting programs of the Directorate for Education and Human Resources (EHR).

NSF sponsors a number of activities directed specifically at bringing members of underrepresented groups into the science and engineering education pipeline and preparing them for potential advancement to the highest levels of leadership. These activities are among those described in this section.

To locate programs that pertain specifically to underrepresented groups, see "Programs for Groups Underrepresented in Science and Engineering."

One of the Foundation's goals is to promote a science and engineering workforce that is globally engaged. To help meet this goal, the Division of International Programs—located in the Directorate for Social, Behavioral, and Economic Sciences (SBE)—offers a variety of programs. For further information, see the SBE section in this Guide, or visit the Division of International Programs web site, http://www.nsf.gov/sbe/int/.

The programs and activities described in this section are organized in the following categories:

- **Programs at the Undergraduate Level**
- **Programs at the Graduate and Postdoctoral Level**
- **Specialized Multilevel Programs**
- **Programs for Faculty and Institutional Development**
- **Programs for Groups Underrepresented in Science and Engineering**

### ⓘ For More Information

For further information about programs for human resource and career development, visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm.

For further information about programs managed by the EHR Directorate, including programs for underrepresented groups, visit the following EHR Division home pages:

–Division of Human Resource Development, http://www.ehr.nsf.gov/EHR/HRD
–Division of Undergraduate Education, http://www.ehr.nsf.gov/EHR/DUE
–Division of Graduate Education, http://www.ehr.nsf.gov/EHR/DGE/

## PROGRAMS AT THE UNDERGRADUATE LEVEL

Activities to enhance undergraduate education in science and engineering are supported throughout NSF. In particular, the **Division of Undergraduate Education (DUE)** in EHR offers focused programs for the education of technologists, primarily through community colleges, and for the education of future teachers. On a broader scale, DUE supports course, curriculum, and laboratory improvement aimed at all undergraduate students, both nonmajors and majors in science and engineering. In addition, some of NSF's disciplinary directorates offer programs in support of course development. Information on these can be found in the directorate sections of this Guide.

NSF is committed to the education of a science and engineering workforce drawn broadly from the Nation's talent pool. To increase diversity at the undergraduate level, NSF offers the **Louis Stokes Alliances for Minority Participation**.

To provide opportunities for participation in research, NSF supports the Research Experiences for Undergraduates (REU).

The REU Program supports active research participation by undergraduate students in science and engineering disciplines supported by NSF. REU projects involve students in meaningful ways in ongoing research and education programs or in projects specially designed for the purpose. Two support mechanisms are offered: REU Supplements and REU Sites. REU Supplements may be included in proposals for new or renewal NSF grants or as supplements to ongoing NSF-funded projects. REU Sites are based on independent proposals to initiate and

conduct undergraduate research and education projects for a number of students. REU Sites projects are often focused within a single discipline and/or single academic department; however, interdisciplinary or multiple-department proposals with a strong intellectual focus are also encouraged, as are proposals with international dimensions. Undergraduate student participants supported with NSF funds in either Supplements or Sites must be citizens or permanent residents of the United States or its possessions.

**ⓘ For More Information**

For program announcement NSF 01-121, a list of contact people, a list of current REU Sites, and other guidance, visit the REU web site, http://www.nsf.gov/home/crssprgm/reu/start.htm.

## PROGRAMS AT THE GRADUATE AND POSTDOCTORAL LEVEL

NSF is a major supporter of graduate and postdoctoral education in science and engineering. The majority of this support is embedded in awards to institutions through funds to support graduate research assistants and postdoctoral associates. NSF also supports fellowships and traineeships in the following programs:

- **Graduate Research Fellowships*** (see http://www.ehr.nsf.gov/dge/programs/grf/)
- **Integrative Graduate Education and Research Traineeship (IGERT) Program*** (see http://www.nsf.gov/home/crssprgm/igert/start.htm)
- **NSF Graduate Teaching Fellows in K–12 Education*** (see http://www.ehr.nsf.gov/dge/programs/gk12/)

*Note: Graduate students supported as Fellows or Trainees in these programs must be citizens or permanent residents of the United States or its possessions.

NSF is committed to the education of a science and engineering workforce drawn broadly from the Nation's talent pool. To increase diversity at the graduate level and beyond, NSF offers the **Alliances for Graduate Education and the Professoriate** (see http://www.ehr.nsf.gov/hrd/agep.asp).

### Postdoctoral Fellowships

In addition to supporting postdoctoral associates through NSF research awards to institutions, NSF offers a number of postdoctoral fellowship programs in specific disciplines.

**ⓘ For More Information**

A complete list of NSF postdoctoral fellowship programs, including contact names, brief program descriptions, links to program announcements, and other helpful information, is available on the NSF FastLane System, https://www.fastlane.nsf.gov/d11/D11Menu.htm.

The following table also lists current postdoctoral fellowship programs and contact information.

| FELLOWSHIP | CONTACT |
|---|---|
| **Minority Postdoctoral Research Fellowships in Biological, Social, Behavioral, and Economic Sciences (NSF 00-139)** | • BIO Minority Research Fellowships<br>Biological Infrastructure<br>National Science Foundation<br>4201 Wilson Blvd., Rm 615<br>Arlington, VA 22230<br>Tel: 703-292-8470<br>http://www.nsf.gov/bio/dbi/dbitraining.htm<br><br>• SBE Minority Research Fellowships<br>Cross-Directorate Activities<br>National Science Foundation<br>4201 Wilson Blvd., Rm 995<br>Arlington, VA 22230<br>Tel: 703-292-8763<br>http://www.nsf.gov/sbe/ses/ip/start.htm |
| **Postdoctoral Research Fellowships in Biological Informatics (NSF 98-162)** | Postdoctoral Research Fellowships<br>in Biological Informatics<br>Biological Infrastructure<br>National Science Foundation<br>4201 Wilson Blvd., Rm 615<br>Arlington, VA 22230<br>Tel: 703-292-8470<br>http://www.nsf.gov/bio/dbi/dbitraining.htm |
| **Postdoctoral Research Fellowships in Microbial Biology (99-142)** | Postdoctoral Research Fellowships in<br>Microbial Biology<br>Biological Infrastructure<br>National Science Foundation<br>4201 Wilson Blvd., Rm 615<br>Arlington, VA 22230<br>Tel: 703-292-8470<br>http://www.nsf.gov/bio/dbi/dbitraining.htm |
| **CISE Postdoctoral Research Associates in Experimental Computer Science (97-169)** | Division of Experimental and<br>Integrative Activities<br>National Science Foundation<br>4201 Wilson Blvd., Rm 1160<br>Arlington, VA 22230<br>Tel: 703-292-8980<br>http://www.cise.nsf.gov/eia/index.html |
| **NSF-NATO Postdoctoral Fellowships in Science and Engineering (NSF 00-145)** | NATO Postdoctoral Fellowship<br>Program<br>Division of Graduate Education |

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| | National Science Foundation<br>4201 Wilson Blvd., Rm 907<br>Arlington, VA 22230<br>Tel: 703-292-8630<br>http://www.ehr.nsf.gov/dge/programs/nato/ |
| **Graduate Student Industrial Fellowship**<br><br>• **Postdoctoral Industrial Fellowship** | Dr. Donald Senich<br>Division of Design, Manufacture, and Industrial Innovation<br>National Science Foundation<br>4201 Wilson Blvd., Rm 527<br>Arlington, VA 22230<br>Tel: 703-292-8330 |
| **Ridge Interdisciplinary Global Experiments (RIDGE) Postdoctoral Fellowship Program (NSF 95-132)** | Division of Ocean Sciences<br>National Science Foundation<br>4201 Wilson Blvd., Rm 725<br>Arlington, VA 22230<br>Tel: 703-292-8580 |
| **NSF Astronomy and Astrophysics Postdoctoral Fellowships (NSF 00-136)** | Division of Astronomical Sciences<br>National Science Foundation<br>4201 Wilson Blvd., Rm 1045<br>Arlington, VA 22230<br>Tel: 703-292-8820<br>e-mail: aapf@nsf.gov |
| **MPS Distinguished International Postdoctoral Research Fellowships (NSF 00-142 and NSF 00-143)** | • Division of Astronomical Sciences<br>Rm 1045; Tel: 703-292-8820<br><br>• Division of Chemistry<br>Rm 1055; Tel: 703-292-8840<br><br>• Division of Materials Research<br>Rm 1065; Tel: 703-292-8810<br><br>• Division of Mathematical Sciences<br>Rm 1025; Tel: 703-292-8870<br><br>• Division of Physics<br>Rm 1015; Tel: 703-292-8890<br><br>National Science Foundation<br>4201 Wilson Blvd.<br>Arlington, VA 22230 |
| • **Mathematical Sciences Postdoctoral Research Fellowships (with Research** | Infrastructure Program<br>Division of Mathematical Sciences<br>National Science Foundation |

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|---|---|
| **Instructorship option) (NSF 01-126)**<br><br>• **Mathematical Sciences University/Industry Postdoctoral Research Fellowships** | 4201 Wilson Blvd., Rm 1025<br>Arlington, VA 22230<br>Tel: 703-292-8870<br>e-mail: msprf@nsf.gov<br>http://www.nsf.gov/mps/divisions/dms/start.htm |
| **International Research Fellowships (NSF 01-135)** | International Research Fellowship Program<br>Division of International Programs<br>National Science Foundation<br>4201 Wilson Blvd., Rm 935<br>Arlington, VA 22230<br>Tel: 703-292-8711<br>http://www.nsf.gov/sbe/int/fellows/start.htm |
| **Japan Society for the Promotion of Science (JSPS) Postdoctoral Awards for U.S. Researchers** | JSPS Postdoctoral Awards<br>Division of International Programs<br>National Science Foundation<br>4201 Wilson Blvd., Rm 935<br>Arlington, VA 22230<br>Tel: 703-292-8704<br>e-mail: NSFJinfo@nsf.gov<br>http://www.nsf.gov/sbe/int/start.htm |

## SPECIALIZED MULTI-LEVEL PROGRAMS

Some NSF programs approach human resource and career development by addressing these issues across several education levels. This approach is used in activities aimed at improving the recruitment and retention of women in careers in science and engineering and at realizing the potential for careers in science and engineering for persons with disabilities. Programs of this type include the following:

- **Program for Gender Equity in Science, Mathematics, Engineering, and Technology**
- **Program for Persons with Disabilities**

### Facilitation Awards for Scientists and Engineers with Disabilities

The Facilitation Awards for Scientists and Engineers with Disabilities (FASED) encourage the participation of scientists and engineers with disabilities (including investigators and other staff, postdoctoral associates, student research assistants, and awardees and honorable mention recipients for graduate fellowships) in NSF programs. This effort provides funds for equipment and for the necessary assistance specifically required for the performance of research on an NSF-supported project. A request for support may be included in a new proposal submitted to any NSF program or in a request for a supplement to an existing NSF grant. When making a request, be sure to check the box "Facilitation for Scientists/Engineers with Disabilities" on NSF Form 1207. Information is also available in program announcement NSF 91-54.

## PROGRAMS FOR FACULTY AND INSTITUTIONAL DEVELOPMENT

One of NSF's core strategies is the integration of research and education. This strategy is embodied in NSF's premier program for early career faculty and in its presidential awards component. NSF also supports faculty members from predominantly undergraduate institutions by enduring their substantial contributions to research and education. Special research and education opportunities are available for these faculty as well as for faculty who are underrepresented minorities. A new pilot program aims to increase the participation and advancement of women in academic careers in science and engineering. Faculty and institutional development opportunities are available from NSF through the following programs:

1. **Faculty Early Career Development**
2. **NSF Component of the Presidential Early Career Awards for Scientists and Engineers**
3. **Research in Undergraduate Institutions and Research Opportunity Awards**
4. **Minority Research Planning Grants and Career Advancement Awards**
5. **ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers**
6. **Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring**

To ensure a broad national base for research, NSF emphasizes developing the research capacity of faculty across a range of institutions, including not only the predominantly undergraduate institutions previously mentioned, but also institutions that have had low participation in NSF programs in the past. The **Experimental Program to Stimulate Competitive Research (EPSCoR)** (see http://www.ehr.nsf.gov/epscor/) is an example of this emphasis.

The following are three examples of specialized programs aimed at the enhancement of research and education in minority-serving institutions:

- **Historically Black Colleges and Universities—Undergraduate Program** (see http://www.ehr.nsf.gov/hrd/hbcu.asp)

- **Tribal Colleges and Universities Program** (see http://www.ehr.nsf.gov/EHR/HRD/tcup.asp)

- **Centers for Research Excellence in Science and Technology** (see http://www.ehr.nsf.gov/hrd/Crest.asp)

**1. Faculty Early Career Development (CAREER)—**An NSF-wide activity that supports junior faculty within the context of their overall career development. It combines in a single program research support and education of the highest quality. CAREER emphasizes the importance NSF places on the early development of academic careers dedicated to stimulating the discovery process in which the excitement of research is enhanced by inspired teaching and enthusiastic learning.

**For More Information**

Visit the CAREER web site, http://www.nsf.gov/home/crssprgm/career/start.htm.

**2. NSF Component of the Presidential Early Career Awards for Scientists and Engineers (PECASE)—**Each year, NSF selects up to 20 nominees for PECASE. Nominees are selected from among the most meritorious first-year awardees supported by the Faculty Early Career Development (CAREER) Program (see description of CAREER above). PECASE recognize outstanding scientists and engineers who early in their careers show exceptional potential for leadership at the frontiers of knowledge. This Presidential award is the highest honor bestowed by the U.S. Government on scientists and engineers who are beginning their independent careers.

**For More Information**

Information about PECASE, including eligibility factors and other pertinent information, is available on the PECASE web site, http://www.nsf.gov/pecase/.

**3. Research in Undergraduate Institutions (RUI)—**Supports research by faculty members from predominantly undergraduate institutions by funding (1) individual and collaborative research projects; (2) the purchase of shared-use research instrumentation; and (3) Research Opportunity Awards for work with NSF-supported investigators from other institutions (these three types of support are described below).

All NSF directorates participate in the RUI activity. RUI proposals are evaluated and funded by the NSF program in the disciplinary area of the proposed research. The objectives of RUI are to support high-quality research, strengthen the research environment in academic departments that are oriented primarily toward undergraduate instruction, and promote the integration of research and education.

The involvement of undergraduate students in a research-rich learning environment is an important feature of RUI. However, the primary purpose of RUI is to support faculty research, thereby maintaining the intellectual vibrancy of faculty members in the classroom and research community.

RUI provides the following types of support:

- Single-Investigator and Collaborative Faculty Research Projects—Provides support through NSF research programs in response to proposals submitted by individual faculty members or by groups of collaborating investigators. RUI proposals differ from standard NSF proposals in that they include an RUI Impact Statement describing the expected effects of the proposed research on the research and education environment of the institution. Please note: the Directorate for Biological

Sciences has special instructions for Collaborative Research at Undergraduate Institutions (C-RUI). See NSF 01-9 for further details.

- Shared Research Instrumentation and Tools—Provides support for (1) the purchase or upgrade of instrumentation or equipment necessary to support research that will be conducted by several faculty members and (2) the development of new instrumentation.

- Research Opportunity Awards (ROA's)—Enable faculty members at predominantly undergraduate institutions to pursue research as visiting scientists with NSF-supported investigators at other institutions. ROA's are usually funded as supplements to ongoing NSF research grants. ROA's are intended to increase visitors' research capability and effectiveness; improve research and teaching at their home institution; and enhance the NSF-funded research of the host principal investigator.

### ⓘ For More Information

For further information about the RUI activity, including guidelines for the preparation and submission of proposals, visit the RUI web site, http://www.ehr.nsf.gov/crssprgm/rui/start.shtm.

Prospective applicants for RUI grants and principal investigators interested in hosting an ROA visiting researcher are urged to contact a program officer in the appropriate discipline.

**4. Minority Research Planning Grants and Career Advancement Awards—** These awards are part of NSF's overall effort to give members of minority groups that are underrepresented in science and engineering greater access to science and engineering research and education support.

- Minority Research Planning Grants (MRPG's)—Enable PIs who have not had prior independent Federal research support to develop competitive research projects by supporting preliminary studies and similar activities. These are one-time awards of up to $18,000 for a maximum of 18 months.

- Minority Career Advancement Awards (MCAA's)—Support activities that can expand the research career potential of promising applicants. These awards are limited to approximately $50,000 for 12 months and in general are one-time nonrenewable grants.

### ⓘ For More Information

The submission deadline date varies with each program. For additional information, contact the appropriate discipline. Information is also available in program announcement NSF 94-147.

**5. ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers—**Seeks to improve the climate for women in U.S. academic institutions and facilitate the advancement of women to the highest ranks of academic leadership. This pilot program especially encourages the use of creative approaches by men and women to meet these goals.

ADVANCE provides award opportunities for individuals and organizations through the following:

- Fellows Awards—Enable promising individuals to establish or reestablish full-time independent academic research and education careers in institutions of higher learning.

- Institutional Transformation Awards—Support academic institutional transformation to promote the increased participation and advancement of women scientists and engineers in academe.

- Leadership Awards—Recognize the outstanding contributions made to date by organizations and individuals that have enabled the increased participation and advancement of women in academic science and engineering careers; and enable awardees to sustain, intensify, and initiate new activities designed to make further progress.

Members of underrepresented minority groups and individuals with disabilities are encouraged to apply for an award.

**ⓘ For More Information**

Visit the ADVANCE web site, http://www.nsf.gov/home/crssprgm/advance/.

**6. Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring (PAESMEM)—**Administered by NSF on behalf of the White House, the PAESMEM Program seeks to identify outstanding mentoring efforts and programs that are designed to enhance the participation of groups traditionally underrepresented in science, mathematics, and engineering.

**ⓘ For More Information**

See program announcement NSF 01-54; or visit the PAESMEM web site, http://www.ehr.nsf.gov/ehr/hrd/paesmem.asp.

## PROGRAMS FOR GROUPS UNDERREPRESENTED IN SCIENCE AND ENGINEERING

NSF has a number of special programs that address members of groups underrepresented in science and engineering. Activities are aimed at increasing the participation of underrepresented minorities (among minorities, these groups include American Indians/Alaska Natives [Native Americans], Blacks [African Americans], Hispanics, and Pacific Islanders); improving the recruitment and retention of women and girls in science and engineering careers; and ensuring that persons with disabilities have the opportunity to participate fully in NSF-supported projects. Such efforts include programs for students, faculty, and institutions designed to develop as fully as possible our Nation's talent pool.

The following is a list of these programs and activities, with reference to their accompanying publication, for further information.

### DIRECTORATE FOR BIOLOGICAL SCIENCES (BIO):

- Minority Postdoctoral Research Fellowships and Supporting Activities (NSF 00-139)

### DIRECTORATE FOR COMPUTER AND INFORMATION SCIENCE AND ENGINEERING (CISE):

- CISE Minority Institutions Infrastructure (NSF 96-15)

- Information Technology Workforce Program (Dear Colleague Letter NSF 01-33)

- CISE Research Resources (NSF 01-100)

### Division of Human Resource Development (HRD), DIRECTORATE FOR EDUCATION AND HUMAN RESOURCES (EHR):

- Alliances for Graduate Education and the Professoriate (NSF 00-53)
- Centers of Research Excellence in Science and Technology (NSF 98-19)
- Tribal Colleges and Universities Program (NSF 01-61)
- Historically Black Colleges and Universities Undergraduate Program (NSF 00-131)
- Louis Stokes Alliances for Minority Participation (NSF 01-14)
- Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring (NSF 00-41)
- Program for Gender Equity in Science, Mathematics, Engineering, and Technology (NSF 01-6)
- Program for Persons with Disabilities (NSF 01-67)

**DIRECTORATE FOR ENGINEERING (ENG):**

- Biomedical Engineering and Research to Aid Persons with Disabilities (NSF 01-12)
- Supplemental Funding for Support of Women, Minorities, and Physically Disabled Engineering Research Assistants (see http://www.eng.nsf.gov/eec/suppfund.htm)

**DIRECTORATE FOR GEOSCIENCES (GEO):**

- Opportunities for Enhancing Diversity in the Geosciences (NSF 01-36)

**DIRECTORATE FOR SOCIAL, BEHAVIORAL, AND ECONOMIC SCIENCES (SBE):**

- Minority Postdoctoral Research Fellowships (NSF 00-136)

**FOUNDATION-WIDE ACTIVITIES:**

- Minority Research Planning Grants and Career Advancement Awards (NSF 94-147). All inquiries should be directed to the appropriate disciplinary program officer.
- Facilitation Awards for Scientists and Engineers with Disabilities (NSF 91-54)
- ADVANCE (NSF 01-69)

## CROSSCUTTING RESEARCH, INSTRUMENTATION, AND PARTNERING PROGRAMS

The programs and activities described in this section are as follows:

1. **Grant Opportunities for Academic Liaison with Industry**
2. **Partnerships for Innovation**
3. **Innovation and Organizational Change**
4. **Global Change Research Programs**
5. **Partnership for a New Generation of Vehicles**
6. **International Programs**
7. **Small Business Innovation Research Program and**
8. **Small Business Technology Transfer Program**
9. **Small Grants for Exploratory Research**
10. **Science and Technology Centers: Integrative Partnerships**
11. **Major Research Instrumentation**
12. **Collaboratives to Integrate Research and Education**

**1. Grant Opportunities for Academic Liaison with Industry (GOALI)—**Aims to synergize university/industry partnerships by making funds available to support these linkages. The program supports (a) faculty, postdoctoral fellows, and students to conduct research and gain experience in an industrial setting; (b) industry scientists and engineers to bring industrial perspective and integrative skills to academe; and (c) interdisciplinary university/industry teams to conduct long-term projects. The program targets high-risk and high-gain research, with focus on fundamental topics that would not otherwise have been undertaken by industry; the development of innovative, collaborative university/industry educational programs; and the direct exchange of new knowledge between academe and industry. GOALI provides (a) funding for individuals such as faculty, postdoctoral fellows, and students to develop creative modes of collaborative interaction with industry through individual or small-group research projects; and (b) industry-based fellowships for graduate students and postdoctoral fellows. All NSF Directorates participate in the GOALI Program at this time.

**ⓘ For More Information**

See program announcement NSF 98-142; or visit the GOALI web site, http://www.nsf.gov/goali/.

**2. Partnerships for Innovation (PFI)—** Seeks to stimulate innovation by supporting partnerships among colleges and universities, State and local governments, the private sector, and other relevant organizations, thus emphasizing the productive connections between new knowledge created in the discovery process and learning and innovation.

For the purpose of this program, innovation explicitly extends to training and developing people and tools and creating organizational conditions necessary to foster the transformation of knowledge into products, processes, systems, and services that will fuel economic development, create wealth, and generate improvement in the national standard of living. Key factors in the innovation enterprise include creating and accessing new knowledge, a scientifically and technologically literate workforce, and infrastructure that will enable innovation. Concurrently, the PFI Program addresses

NSF's strategic intention to broaden participation of people and institutions in NSF activities.

The goals of the PFI Program are

- to catalyze partnerships for innovation that will enable the transformation of knowledge created by the national research and education enterprise into innovations that create new wealth, build strong local, regional, and national economies; and improve the national well-being;

- to broaden the participation of all types of academic institutions and of citizens in NSF activities to better meet the broad workforce needs of the national innovation enterprise; and

- to create enabling infrastructure necessary to foster and sustain innovation for the long term.

Examples of proposals that might be submitted to the PFI Program are those that include planning and/or implementation of new models for innovation; education and training activities that explicitly address the workforce needs of the innovation enterprise; and development and deployment of new tools or mechanisms that support the innovation infrastructure. They may seek to create an activity focusing on a critical level of innovation in a technological area in an industrial sector or in a geographical region. The outcomes for proposed activities should foster economic and/or societal well-being that can be self-sustaining in the long-term. The lead organization must be a degree-granting academic institution of higher learning. At a minimum, proposed partnerships must include private-sector organizations or State/local government entities.

### For More Information

Contact John C. Hurt, Program Director, by telephone, 703-292-5332; or by e-mail, jhurt@nsf.gov. A complete list of awards made by the program including project descriptions is available at http://www.nsf.gov/od/lpa/news/press/00/pr0068.htm. Further information is also available in program announcement NSF 01-79.

**3. Innovation and Organizational Change (IOC)—**Seeks to improve the performance of industrial, educational, service, health care, government, and other organizations and institutions through the support of research on theories, concepts, and methodologies of innovation and organizational change. To foster innovation and manage change, we need to understand effective approaches to organizational learning and redesign; strategic and cultural change; quality and process improvement; innovation; new product and service development; and the development and integration of new technologies. The program supports research using theory combined with empirical validation to clarify effective approaches to organizational learning and redesign; strategic and cultural change; quality and process improvement; innovation; new product and service development; and the development and integration of new technologies.

IOC is jointly sponsored by the Directorates for Social, Behavioral, and Economic Sciences; Engineering; and Education and Human Resources.

### For More Information

Visit the program's web site at http://www.nsf.gov/sbe/ses/ioc/start.htm.

**4. Global Change Research Programs (GCRP's)—**NSF GCRP's support research and related activities that advance fundamental understanding of dynamic physical, biological, and socioeconomic systems as well as interactions among those systems. In addition to research on Earth system processes and the consequences of changes in those systems, NSF programs facilitate data acquisition and data management activities necessary for basic research on global change, promote the enhancement of modeling designed to improve representation of Earth system interactions, and develop advanced analytic methods to facilitate fundamental research. NSF also supports fundamental research on processes to identify and evaluate responses to changing global environmental conditions.

### For More Information

A list of NSF-sponsored global change research programs and further information about each is available on the GCRP web site at http://www.nsf.gov/geo/egch/.

**5. Partnership for a New Generation of Vehicles (PNGV)—**PNGV is a historic public/private partnership between the Federal Government (including 7 agencies and 19 Federal laboratories) and DaimlerChrysler, Ford, and General Motors Corporations that aims to strengthen America's competitiveness by developing technologies for a new generation of vehicles.

PNGV's long-term goals are (1) to develop an environmentally friendly car with up to triple the fuel efficiency of today's midsize cars; (2) to significantly improve national competitiveness in automotive manufacturing; and (3) to apply commercially viable innovation to conventional vehicles. PNGV's success is important to the country for a number of reasons, primarily jobs and global competitiveness (one out of every seven jobs in the United States is automotive related); reduction of U.S. dependence on foreign oil (the United States currently

imports 50 percent of the oil it consumes); and environmental factors (automobiles are a major contributor to atmospheric carbon dioxide, a greenhouse gas).

### ⓘ For More Information

Write to the PNGV Secretariat, U.S. Department of Commerce, Herbert Hoover Building, Room 4845, 14th Street & Constitution Ave., NW, Washington, DC 20230; or contact by telephone, 202-482-6260, or by fax, 202-482-6275. To inquire via e-mail, send messages to pngv-info@ta.doc.gov with "PNGV Question" as the subject line.

**6. International Programs—**Support of international activities is an integral part of NSF's mission to promote the progress of U.S. science and engineering. In particular, NSF recognizes the importance of (1) enabling U.S. researchers and educators to advance their work through international collaboration and (2) helping ensure that future generations of U.S. scientists and engineers gain professional experience overseas early in their careers. Consistent with the international character of science and engineering, disciplinary programs throughout NSF offer support to U.S. scientists and engineers for the international aspects of their research when those aspects are judged to be important to the specific objectives of those activities.

The Division of International Programs (INT) in the Social, Behavioral, and Economic Sciences Directorate expands and facilitates the international dimensions of NSF's mission by promoting new partnerships between U.S. scientists and engineers and their foreign colleagues. Most INT programs are organized on a regional or country basis. Prospective applicants should also consider international opportunities supported by other parts of NSF and elsewhere.

### ⓘ For More Information

Information and guidelines on proposal preparation for international programs and activities are available in program announcement NSF 00-138; or visit the INT web site at http://www.nsf.gov/sbe/int.

**7. Small Business Innovation Research Program and Small Business Technology Transfer Program—**

- **Small Business Innovation Research (SBIR) Program—**NSF encourages small businesses to submit high-quality proposals that focus on important science, engineering, and science/engineering education problems and opportunities and that will lead to significant commercial and public benefit. The SBIR Program is a Government-wide program intended to stimulate technological innovation, use small-business concerns to meet Federal research and development (R&D) needs, foster and encourage the participation of minority and disadvantaged persons in technological innovation, and increase the commercialization by the private sector of innovations resulting from Federal R&D.

SBIR uses a uniform three-phase process. Phase I is a 6-month effort designed to evaluate the feasibility of an idea based on its scientific and technical merit. Phase II builds on the feasibility study and leads to the development of a model or prototype. Phase III is the commercialization phase. Development of a partnership with another funding source is strongly encouraged and is one of the measures used in the evaluation of Phase II proposals. SBIR funds are not used for Phase III efforts.

SBIR is highly competitive and supports the Nation's small high-tech businesses, universities, and research institutions that are able to convert basic ideas and research into commercial products that will enhance the Nation's productivity and help maintain its competitive leadership in the international marketplace.

The small business can partner with other businesses or nonprofit institutions such as academic or Government

laboratories. In Phase I, the partner's participation can be 33 and a third percent, and in Phase II, up to 50 percent. Members of academic institutions can participate either through a subcontract to the institution or as consultants.

### For More Information about SBIR

Visit the SBIR web site at http://www.eng.nsf.gov/sbir/.

- **Small Business Technology Transfer (STTR) Program—**Also a Government-wide program, STTR differs from SBIR in that it requires the small business to engage in cooperative research with nonprofit research institutions. STTR is also a three-phase process. Phase I is a 12-month effort that determines scientific, technical, and commercial merit and establishes concept feasibility and eligibility for Phase II. Phase II further develops the proposed idea while taking into consideration scientific, technical, and commercial merit; Phase I results; and other relevant information. Phase III involves the commercial application of the research funded in Phases I and II. STTR funds are not used for Phase III efforts.

STTR is highly competitive and supports the Nation's small high-tech businesses, universities, and research institutions that are able to convert basic ideas and research into commercial products that will enhance the Nation's productivity and help maintain its competitive leadership in the international marketplace.

The small business must partner with a federally funded research and development center, university, or nonprofit institution. In both Phase I and Phase II, the participation must amount to a minimum of 40 percent of the effort for the small-business concern and 30 percent of the effort for the research institution. Members of the academic or research institution participate through a subcontract to the institution. Before starting Phase I, the partners make an agreement that covers rights to the technology involved in the proposal.

### For More Information

Visit the STTR web site at http://www.eng.nsf.gov/sbir/.

**8. Small Grants for Exploratory Research (SGER)—**Proposals for small-scale, exploratory, and high-risk research in the fields of science, engineering, and education normally supported by NSF may be submitted to individual programs. Such research is characterized as preliminary work on untested and novel ideas; ventures into emerging research ideas; the application of new expertise or new approaches to “established” research topics; having extreme urgency with regard to availability of or access to data, facilities, or specialized equipment, including quick-response research on natural disasters and similar unanticipated events; and efforts of similar character likely to catalyze rapid and innovative advances.

NSF strongly encourages investigators to contact the NSF program officer(s) most germane to the proposal topic before submitting an SGER proposal. This will make it easier to determine whether the proposed work meets the SGER guidelines described here and the availability for funding, or whether it would be more suitable for submission as a fully reviewed proposal.

The project description must be two to five pages long. It should include a clear statement that explains why the proposed research should be considered particularly exploratory and high risk and the nature and significance of its potential impact on the field. In addition, an explanation should be included as to why an SGER grant would be the best means of supporting the work.

Brief biographical information is required for the principal investigator (PI) and co-PI(s) only, and should include a list of no more than five significant publications or other

research products. The box for “Small Grant for Exploratory Research” must be checked on the cover sheet.

These proposals will be subject to internal NSF merit review only. Renewed funding of SGER awards may be requested only through submission of a non-SGER proposal that will be subject to full merit review. The maximum SGER award amount will not exceed $100,000. Although the maximum award amount is $100,000, the award amount usually will be substantially less than a given program’s average award amount. The project’s duration will normally be 1 year, but may be up to 2 years.

For participating directorates and at the discretion of the program officer with the concurrence of the division director, a small fraction of especially promising SGER awards may be extended for up to 6 additional months and supplemented with up to $50,000 in additional funding.

These award extensions will be possible for awards with an initial duration of 2 years or less. Requests for extensions must be submitted 1 to 2 months before the expiration date of the initial award. A project report and an outline of the proposed research (not to exceed five pages) must be included.

**9. Science and Technology Centers: Integrative Partnerships (STC)—**The STC Program was established in 1987 to fund important basic research and education activities and to encourage technology transfer and innovative approaches to interdisciplinary activities. Since its inception, 30 comprehensive STC’s have been established.

The STC’s explore new areas and build bridges among disciplines, institutions, and other sectors. They offer the research community an effective mechanism to embark upon long-term scientific and technological research activities, explore better and more effective ways to educate students, and develop mechanisms to ensure the timely transition of research and education advances made into service in society.

**ⓘ For More Information**

Write to the Office of Integrative Activities (OIA), National Science Foundation, 4201 Wilson Boulevard, Room 1270, Arlington, VA 22230; or contact by telephone, 703-292-8040, or by e-mail, nsf_oia@nsf.gov; or visit the OIA home page at http://www.nsf.gov/od/oia/start.htm.

**10. Major Research Instrumentation (MRI)—**Is designed to improve the condition of scientific and engineering (S&E) equipment used for research and research training in our Nation's academic institutions. The program works to improve the quality and expand the scope of research and research training in S&E and foster the integration of research and education by providing instrumentation for research-intensive learning environments.

The MRI Program assists in the acquisition or development by U.S. institutions of major research instrumentation that is generally too costly to support through other NSF programs. Maintenance and technical support associated with these instruments is also supported. Proposals may be for a single instrument, a large system of instruments, or multiple instruments that share a common research focus. Computer systems, clusters of advanced workstations, networks, and other information infrastructure components necessary for research are supported.

**ⓘ For More Information**

Write to the Office of Integrative Activities (OIA), National Science Foundation, 4201 Wilson Boulevard, Room 1270, Arlington, VA 22230; or contact by telephone, 703-292-8040, or by e-mail, nsf_oia@nsf.gov; or visit the OIA home page, http://www.nsf.gov/od/oia/start.htm. http://www.nsf.gov

**11. Collaboratives to Integrate Research and Education (CIRE)—**CIRE was created to establish long-term research and education relationships between minority-serving institutions and NSF-supported facilities and centers. CIRE's long-term goal is to formally establish these developing relationships by negotiating formal institution-to-institution agreements for their continuation and support. Examples of the types of activities supported by CIRE are (1) the development of collaborative and mutually beneficial research and education projects that may include infrastructure enhancement at the minority-serving institution, if needed, to support the proposed collaborative activity; and (2) exchanges of faculty and students. It should be noted however, that CIRE is not a general infrastructure program for minority-serving institutions. Funds to support CIRE-like activities come from the cognizant research directorate. Therefore, communication should be made with the Office of the Assistant Director of the cognizant directorate.

### ⓘ For More Information

Write to the Office of Integrative Activities (OIA), National Science Foundation, 4201 Wilson Boulevard, Room 1270, Arlington, VA 22230; or contact by telephone, 703-292-8040, or by e-mail, nsf_oia@nsf.gov; or visit the OIA home page, http://www.nsf.gov/od/oia/start.htm.

# BIOLOGICAL SCIENCES

The Directorate for Biological Sciences (BIO) promotes and advances scientific progress in biology, largely through grants to colleges, universities, and other institutions, especially in those areas where the National Science Foundation (NSF) has major responsibility. NSF is the Nation's principal supporter of fundamental academic research on plant biology, environmental biology, and biodiversity. It provides support for research to advance understanding of the underlying principles and mechanisms governing life. Research ranges from the study of the structure and dynamics of biological molecules such as proteins and nucleic acids; to studies of cells, organs, and organisms; to studies of populations and ecosystems. NSF encompasses processes that are internal to an organism and those that are external, and includes temporal frameworks ranging from measurements in real time through individual life spans, to the full scope of evolutionary time.

The BIO Directorate supports programs and activities through the following:

- **Division of Biological Infrastructure (DBI)**
- **Division of Environmental Biology (DEB)**
- **Division of Integrative Biology and Neuroscience (IBN)**
- **Division of Molecular and Cellular Biosciences (MCB)**
- **Crosscutting Programs and Activities (including the Plant Genome Research Program)**

**Eligibility Requirements for BIO Proposals**

The most frequent recipients of support for basic scientific research in the biological sciences are academic institutions and nonprofit research organizations. In special circumstances, grants are awarded to other types of institutions and to individuals. In these cases, preliminary inquiry should be made to the appropriate program officer before a proposal is submitted. Support may be provided for projects involving a single scientist or a number of scientists. Awards are made for projects confined to a single disciplinary area and for those that cross or merge disciplinary interests.

**Multi–Investigator Proposals in the BIO Directorate**

Increasingly, many important research problems in science can best be addressed by groups of investigators. A group approach may result in a more comprehensive treatment of many scientific problems, and also may provide innovative opportunities for training students.

The need for increased attention to research and training in biology by multiple principal investigators (PI's) has been identified by several workshops, such as the "NSF/BIO Workshop on Impact of Emerging Technologies on the Biological Sciences," and by advisory committees such as the NSF Biological Sciences Advisory Committee. In response to these recommendations, the BIO Directorate encourages proposals from three or more investigators, who may come from more than one academic institution, to partake in collaborative studies focused on a single problem. BIO programs will evaluate

these proposals in addition to proposals received from individual PI's, as part of a program's portfolio of activities within their existing budget. As is the case for proposals from individual investigators, multi-PI proposals may provide for the training of students and may also involve industrial collaborations, if appropriate. Investigators interested in submitting a multi-PI proposal should contact the appropriate BIO program for further advice and guidance.

**Submission of Proposals to the BIO Directorate**

All proposals directed to NSF must be submitted through NSF's FastLane system. For details about this policy, see the latest NSF *Grant Proposal Guide* (see http://www.nsf.gov/cgi-bin/getpub?gpg for latest version). General information about FastLane is available at http://www.fastlane.nsf.gov/.

Incoming proposals are assigned to program officers within the BIO Directorate's divisions for merit review and recommendation. Normally, support is not provided for bioscience research with disease-related goals, including work on the etiology, diagnosis, and treatment of physical and mental disease, abnormality, or malfunction in human beings or animals. Animal models of such conditions and the development and testing of drugs and other procedures for their treatment also are not eligible for support.

Review of duplicate proposals that have been sent to another Federal agency will be suspended until the other agency takes final action. Exceptions are made for proposals from beginning investigators, for conferences or workshops, and for fellowships, as well as for cases in which a proposer and the Federal program managers have previously agreed to a joint review and possibly joint funding. A beginning investigator is defined as an individual who has not previously been a PI on any federally funded award except a doctoral dissertation improvement grant, fellowship, or research planning grant. Applicants are encouraged to contact a program officer by telephone or e-mail concerning their proposals.

**Deadlines and Target Dates for BIO Programs and Activities**

Many programs in the BIO Directorate have an established deadline or target date for the submission of proposals. To confirm a date, refer to the electronic NSF E-Bulletin, http://www.nsf.gov/home/ebulletin/; or visit the BIO Directorate home page, http://www.nsf.gov/bio/; or contact the appropriate program director. The earliest possible effective date for an award is approximately 6 months after the target or deadline date. Unless there is a program announcement stating otherwise, proposals must conform to all format requirements in the NSF *Grant Proposal Guide* (see http://www.nsf.gov/cgi-bin/getpub?gpg for latest version) with special attention paid to page limitations, font size, and appendix materials. Some programs or specific competitions have program announcements that provide more details about the activities described in this guide.

# DIVISION OF BIOLOGICAL INFRASTRUCTURE

The programs in the Division of Biological Infrastructure (DBI) support activities that provide the infrastructure for contemporary research in biology.

DBI supports research through the following program clusters:

- **Instrument-Related Activities**
- **Research Resources**
- **Training**

In addition, DBI administers the Plant Genome Research Program (see program announcement NSF 00-151). Further information is available on the program's web page at http://www.nsf.gov/bio/dbi/dbi_pgr.htm.

### ⓘ For More Information

Write to the Division of Biological Infrastructure, National Science Foundation, 4201 Wilson Boulevard, Room 615, Arlington, VA 22230; or contact the division by telephone, 703-292-8470; or visit the DBI home page, http://www.nsf.gov:/bio/dbi/start.htm.

## INSTRUMENT-RELATED ACTIVITIES CLUSTER

This cluster of programs is located within the Division of Biological Infrastructure and consists of the following:

1. **Multi-User Equipment and Instrumentation Resources for Biological Sciences**
2. **Instrument Development for Biological Research**
3. **Improvements in Facilities, Communications, and Equipment at Biological Field Stations and Marine Laboratories**

### ⓘ For More Information

Visit the cluster's web site, http://www.nsf.gov/bio/dbi/dbi_instrument.htm.

**1. Multi-User Equipment and Instrumentation Resources for Biological Sciences—** Provides cost-shared support for the acquisition of major items of specialized multi-user instrumentation, thereby providing access to state-of-the-art instruments. The instrumentation must be used in the conduct of research that falls within the purview of the BIO Directorate. The institution is required to share the capital cost.

- *Research at Undergraduate Institutions (RUI) Proposals for Multi-User Equipment and Instrumentation Resources for Biological Sciences*—The Multi-User Equipment and Instrumentation Resources for Biological Sciences Program (see program announcement NSF 98-137) accepts proposals through the RUI Program (see program announcement NSF 00-144). The Multi-User Equipment Program requires that one of the principal investigators be actively receiving NSF funding for research. NSF recognizes that research in NSF-funded areas at RUI institutions is often supported by other sources. Therefore, for RUI institutions, the program makes an exception to the requirement for active NSF research funding provided that (1) the user group is conducting research in NSF-supported subject areas and (2) the user group is able to show adequate research support from other funding sources (such as private foundations or institutional research support) to support the proposed research activities.

- *Joint NSF/NIH Multi-User Instrumentation Activity*—Offers support for the purchase of a single instrument with a total purchase cost exceeding $500,000. Proposals that would normally be eligible for submission to both the National Institutes of Health (NIH) and NSF may be submitted to NIH for joint funding with NSF. Proposers must include the necessary NSF documentation, as summarized in program announcement NSF 98-137. Proposals will be evaluated by the agencies in a special review group that will be convened by NIH as a special NIH study section, with NSF participation. A program announcement for shared instrumentation grants will be published in the January issue of the *NIH Guide for Grants and Contracts*. There is one annual deadline date (usually in the last week of March) for receipt of applications.

**2. Instrument Development for Biological Research—**Supports the development of new instrumentation to increase the accuracy, range, or sensitivity of observations for BIO research fields, including development of concept and proof of concept for entirely new instruments; development of new instruments that will provide new capabilities or significantly extend currently achievable sensitivity or resolution; and improved or novel software for the operation of instruments or the analysis of data or images. For more information, see program announcement NSF 98-119.

**3. Improvements in Facilities, Communications, and Equipment at Biological Field Stations and Marine Laboratories—**Biological Field Stations and Marine Laboratories (FSML's) are off-campus facilities for research and education conducted in the natural habitats of terrestrial, freshwater, and marine ecosystems. FSML's support biological research and education by preserving access to study areas and organisms, providing facilities and equipment in close proximity to those study areas, and fostering an atmosphere of mutual scientific interest and collaboration in research and education. To fulfill these roles, FSML's must offer modern laboratories and educational spaces, up-to-date equipment, appropriate personal accommodations for visiting scientists and students, and modern communications and data management systems for a broad array of users. In recognition of the importance of FSML's in modern biology, NSF invites proposals that address these general goals of FSML improvement. For more information, see program guidelines NSF 01-59.

## RESEARCH RESOURCES CLUSTER

This cluster of programs is located within the Division of Biological Infrastructure and consists of the following:

1. **Biological Databases and Informatics**
2. **Support of Living Stock Collections**
3. **Biological Research Collections**

### ⓘ For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/dbi/dbiresearch.htm.

**1. Biological Databases and Informatics—**Encourages support of new approaches to the management of biological knowledge that render the collection, maintenance, dissemination, and query of the data and information therein of greater use to the scientific community. For more information, see program announcement NSF 99-91.

**2. Support of Living Stock Collections—**Supports repositories of research organisms, genetic stocks, and seeds, as well as cell lines and DNA clones that are associated with the whole organisms in the collection. The resources supported by this program are considered essential for national or international scientific research in the biological sciences. Funds are also provided for curatorial databases and for linking the information associated with the collection to other information resources or scientific databases. Long-term support of a collection or repository will require the development and

use of such databases. For more information, see program announcement and guidelines NSF 97-80.

**3. Biological Research Collections—** Provides support for collection improvement, collection computerization, research on curatorial and collection management techniques, and community-based development activities. Supplements are also provided to underwrite the involvement of undergraduate and high school students in collection-based research. For more information, see program announcement NSF 98-126.

## TRAINING CLUSTER

This cluster of programs is located within the Division of Biological Infrastructure and supports training-related activities. It consists of the following:

1. **Research Experiences for Undergraduates Sites**
2. **Collaborative Research at Undergraduate Institutions**
3. **Integrative Graduate Education and Research Training**
4. **Postdoctoral Research Fellowships, including**
   - **–Minority Postdoctoral Research Fellowships**
   - **–Postdoctoral Research Fellowships in Biological Informatics**
   - **–Postdoctoral Research Fellowships in Microbial Biology**

**ⓘ For More Information**

Visit the cluster's web site, http://www.nsf.gov:/bio/dbi/dbitraining.htm.

**1. Research Experiences for Undergraduates (REU) Sites—**Provides opportunities for undergraduate students to experience hands-on participation in research and related scholarly activities. BIO provides support to grantees who involve students in special training programs and ongoing research through the REU Sites Program. For more information, see program announcement NSF 01-121.

**2. Collaborative Research at Undergraduate Institutions (C-RUI)—**The overall goals of C-RUI have now been incorporated into the NSF-wide program Research at Undergraduate Institutions (RUI) (see program announcement NSF 00-144). It is the intention of the BIO Directorate to participate in this activity by continuing the C-RUI activity that began in fiscal year 1995 and continued in fiscal years 1997 and 1999. We would like to assure the biology community of BIO's commitment to C-RUI activities and encourage qualified investigators at undergraduate institutions to apply for collaborative research funding. BIO further encourages applicants whose research would especially benefit from forging a collaboration with their colleagues across traditional disciplinary lines and, in doing so, offer their students exposure to a multidisciplinary research environment. For further details, see Dear Colleague Letter NSF 01-9.

**3. Integrative Graduate Education and Research Training (IGERT)—**The agency-wide IGERT Program was created by NSF to meet the need for a cadre of broadly prepared Ph.D.'s with the technical, professional, and personal skills essential to address the varied career demands of the future. The IGERT Initiative sponsors development of innovative, research-based graduate education and training programs in Ph.D.-degree-granting institutions. The program supports projects that are based on multidisciplinary research themes and organized by diverse groups of investigators with appropriate research and teaching expertise. The use of a multi-disciplinary research theme provides a framework for the integration of research and education activities, and for collaborative efforts in training that span disciplinary areas. Thus, an IGERT project may involve investigators from one or more departments within a single institution or from more than

one institution. The emphasis of the IGERT Program is on the training of graduate students; however, the program will support efforts that include undergraduate and/or postdoctoral training if such participation will strengthen the proposed training program.

### ⓘ For More Information

Information such as the IGERT program solicitation NSF 00-78, answers to frequently asked questions about the program, detailed instructions on preparing and submitting an IGERT preproposal or formal proposal, and the names of the appropriate NSF staff are available on the IGERT web site, http://www.nsf.gov/home/crssprgm/igert/start.htm.

**4. Postdoctoral Research Fellowships—** These fellowships are offered in select program areas to U.S. citizens, nationals, and lawfully admitted permanent resident aliens. Applicants choose a sponsoring scientist and present a research and training plan. These fellowships are awarded to individuals for research and training at any appropriate U.S. or foreign institution for 2 years, and require a change from the Ph.D. institution.

The BIO Directorate offers postdoctoral research fellowships in selected areas of biology to provide opportunities for recent doctoral scientists to obtain additional training; gain research experience under the sponsorship of established scientists; and broaden their scientific horizons beyond their research experiences during their undergraduate or graduate training. These fellowships are further designed to assist new scientists to direct their research efforts across traditional disciplinary lines and to offer them unique research resources, sites, and facilities, including foreign locations. NSF postdoctoral fellowships are awarded to individuals, and applications are submitted directly by the applicant to NSF. Fellows must affiliate with an appropriate research institution and are expected to devote themselves full time to the fellowship activities for the duration of the fellowship. At the conclusion of the fellowship, a fellow who accepts a tenure-track appointment at a U.S. institution deemed eligible to receive NSF funds may apply for a research starter grant. This program seeks to encourage research and training at the postdoctoral level at the intersection of biology and the informational, computational, mathematical, and statistical sciences. Specific activities are described below. Complete information, including deadline dates and program announcement numbers, is available at http://www.nsf.gov:/bio/dbi/dbitraining.htm#pr.

- *Minority Postdoctoral Research Fellowships*—Seek to prepare minority scientists who are within 4 years of receipt of their doctoral degrees for leadership positions in academe and industry. The term "minority," as used here, refers to those racial or ethnic groups that are significantly underrepresented at advanced levels of science and engineering in the United States. They include American Indians or Alaska Natives (Native Americans), Blacks (African Americans), Hispanics, and Pacific Islanders. Tenure at a foreign institution can be followed by an additional third year of support at a U.S. institution. Fellows are invited to an annual meeting at NSF and are eligible to apply for research starter grants. Minority graduate students within 18 months of their doctoral degrees are eligible for travel awards to visit prospective sponsors before they prepare a fellowship application. For more information, see program announcement NSF 00-139.

- *Postdoctoral Research Fellowships in Biological Informatics*—Provide training to young scientists in preparation for careers in biological informatics where research and education will be integrated. There is an increasing need for training in biological informatics at all occupational levels, and it is expected that the recipients of these fellowships will play an important role in training the future workforce.

- *Postdoctoral Research Fellowships in Microbial Biology*—Support training and research on the basic biology of protozoan, microalgal, fungal, archaeal, bacterial, and viral species that are not generally

considered to be model organisms, such as E. coli, Saccharomyces cerevesiae, or tobacco mosaic virus (TMV). The use of model organisms in comparative studies with nonmodel organisms is not excluded. Studies of the interactions of these microbes with each other and with plants and animals (e.g., symbiosis) may also be supported. Applicants are reminded that BIO does not support research with disease-related goals, including the etiology, diagnosis, or treatment of physical or mental disease, abnormality, or malfunction in human beings or animals. Animal or plant models of such conditions or the development or testing of drugs or other procedures for their treatment are also not eligible for support.

# DIVISION OF ENVIRONMENTAL BIOLOGY

The Division of Environmental Biology (DEB) supports fundamental research on the origins, functions, relationships, interactions, and evolutionary history of populations, species, communities, and ecosystems. Scientific emphases include biodiversity, molecular genetic and genomic evolution, mesoscale ecology, conservation biology, global change, and restoration ecology.

DEB also supports computational biology research (including modeling); a network of long-term ecological research sites; doctoral dissertation research; research conferences and workshops; Undergraduate Mentoring in Environmental Biology; and a variety of other NSF-wide activities.

DEB supports research through the following program clusters:

- **Systematic and Population Biology**
- **Ecological Studies**

### ⓘ For More Information

Write to the Division of Environmental Biology, National Science Foundation, 4201 Wilson Boulevard, Room 635, Arlington, VA 22230; or contact the division by telephone, 703-292-8480; or visit the DEB home page, http://www.nsf.gov:/bio/deb/start.htm.

## SYSTEMATIC AND POPULATION BIOLOGY CLUSTER

This cluster of programs is located within the Division of Environmental Biology and supports research on the patterns and causes of diversity within and among populations and species. Research projects may involve any group of organisms, including terrestrial, freshwater, and marine taxa, and may range in subject from microbes to multicellular plants, animals, and fungi.

The cluster consists of the following:

1. **Population Biology**
2. **Systematic Biology**
3. **Biotic Surveys and Inventories**

### ⓘ For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/deb/debsysbio.htm.

**1. Population Biology—**Focuses on measures of population properties and understanding processes that lead to variation within and between populations. Approaches include empirical and theoretical studies of population structure and dynamics, microevolution, organismal adaptation, geographical differentiation, natural hybridization and speciation, and processes that lead to macroevolutionary patterns of trait evolution. Research areas include

- *Population Ecology*—Supports studies of single species from an ecological and evolutionary perspective, including life

history and life-cycle phenomena of terrestrial, freshwater, and wetland organisms; demography of age- and stage-structured populations; population dynamics, including linear, nonlinear, and stochastic approaches; and patterns of natural and sexual selection.

- *Evolutionary Genetics*—Supports studies of the causes and consequences of variation, change, selection, and evolution of biochemical characteristics, RNA and DNA sequences, mobile elements, and genic organization and function; the evolution of genetic architecture; evolutionary genomics; and population and quantitative genetics.

- *Evolution of Phenotypes*—Supports studies of how the properties of genes (number, arrangement, and pattern) and their interactions, including epigenetics and development, determine evolutionary processes; and how micro- and macro-evolutionary processes explain the evolution of complex phenotypes.

Other programs within NSF also support research that addresses aspects of ecology and evolutionary biology. Studies that focus on organism-centered analyses of physiology, morphology, behavior, or development should be directed to programs in the Division of Integrative Biology and Neuroscience (IBN) (see information on IBN in the Neuroscience Cluster section of this BIO chapter). Studies that focus on marine organisms should be directed to the Biological Oceanography Program in the Division of Ocean Sciences (see the Directorate for Geosciences chapter). Studies that focus on interactions among species should be directed to the Ecology Program (see the Ecological Studies Cluster, the next section in this chapter). Interdisciplinary studies are welcome.

**2. Systematic Biology—**Main focus areas of this program include (a) phylogenetic analyses that produce or test phylogenetic hypotheses or models and the use of derived phylogenies to elucidate patterns of structural, developmental, or molecular evolution; (b) studies that lead to improved classifications, better methods of taxonomic identification, contributions to classificatory theory, and nomenclature reform (included here are the Special Competitions for Partnerships for Enhancing Expertise in Taxonomy, the deadline dates for which are announced via special solicitation (see program announcement and guidelines NSF 00-140); (c) understanding of processes that underlie the origin and maintenance of taxonomic diversity; and (d) theoretical and empirical studies of biogeographical, coevolutionary, and paleobiological patterns to develop models of the origin, diversification, distribution, and extinction of species and evolutionary lineages, and to determine the tempo and mode of evolutionary change.

**3. Biotic Surveys and Inventories—**Main focus areas of this program include collecting and recording the diversity of life on Earth. Permanent, well-curated collections and computerized databases are strongly encouraged as products of the program's support. For more information, see program announcement NSF 98-158.

## ECOLOGICAL STUDIES CLUSTER

This cluster of programs is located within the Division of Environmental Biology and supports research on natural and managed ecological systems, primarily in terrestrial, wetland, and freshwater habitats. Research areas include experimental, theoretical, and modeling studies on the structure and function of complex biotic/abiotic associations and the coupling of small-scale systems to each other and to large-scale systems. Projects are encouraged that develop conceptual and synthetic linkages, such as theoretical and modeling studies; that are conducted at one or more scales of ecological organization; and that synthesize empirical and theoretical findings into new ecological paradigms.

The cluster consists of the following:

1. **Ecosystem Studies**
2. **Ecology**

3. **Long-Term Ecological Research**
4. **Long-Term Research in Environmental Biology**

### ⓘ For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/deb/debecological.htm.

**1. Ecosystem Studies—**Research supported includes mechanistic or empirical investigations of whole-system ecological processes and relationships in the following areas: biogeochemistry (such as studies of decomposition), global and regional elemental budgets, and biotic versus abiotic controls of nutrient cycles; primary productivity, particularly ecophysiology within an ecosystem framework; and landscape dynamics, with an emphasis on quantitative models of disturbances, ecosystem resilience, and successional patterns.

**2. Ecology—**Supports community ecology and population interactions in such areas as dynamics and processes within specific communities or habitats; food-web structure and landscape patterns formed by community dynamics; paleoecology; and organismal interactions, such as mutualism, plant/animal interactions, competition, predation, coevolution, and chemical or evolutionary ecology.

**3. Long-Term Ecological Research (LTER)—**Supports investigations of whole ecosystems and their component organisms and processes at sites that represent major biomes. Projects are multidisciplinary and actively encourage collaborative research with non-ecological investigators. The deadline date for submission of proposals is announced only via special solicitations; unsolicited proposals will not be accepted.

**4. Long-Term Research in Environmental Biology (LTREB)—**Supports smaller studies that focus on evolutionary or ecological phenomena and that require long-term investigation. These awards are designed to provide funding to help maintain an ongoing long-term research project. LTREB awards are *not* a source of startup funds to initiate long-term research, nor does DEB envision that LTREB projects will be the main source of extramural support for investigators. For further information, visit the LTREB web site at http://www.nsf.gov/bio/progdes/ltreb.htm.

## DIVISION OF INTEGRATIVE BIOLOGY AND NEUROSCIENCE

The Division of Integrative Biology and Neuroscience (IBN) supports research aimed at understanding the living organism—plant, animal, microbe—as a unit of biological organization. Such research encompasses

- the mechanisms by which plants and animals develop, grow, reproduce, regulate their physiological activity, and respond to their environment;
- the integration of molecular, subcellular, cellular, and functional genomics approaches to understand the development, functioning, and behavior of organisms in both laboratory and natural settings;
- all aspects of the nervous system, including its structure, function, development, and integration with the physiological and behavioral systems affected by it;
- factors influencing the behavior of animals in the laboratory and field;
- whole-organism approaches to physiological ecology; and
- the form and function of organisms in view of their evolution and environmental interactions.

Synthetic and analytic approaches that address this integration often require advanced computational techniques and interdisciplinary perspectives involving other areas of biology, behavioral science, physical science, mathematics, engineering, and computer science. In addition, the development and use of a wide diversity of organisms as biological models are encouraged to assist both in identifying unifying principles common to all organisms and in documenting the variety of mechanisms that have evolved in specific organisms. Current scientific emphases include biotechnology, biomolecular materials, environmental biology, global change, biodiversity, molecular evolution, plant science, microbial biology, and computational biology, including modeling. Research projects generally include support for the education and training of future scientists.

The IBN Division also supports doctoral dissertation research; research conferences, workshops, and symposia; computational biology research; Undergraduate Mentoring in Environmental Biology; and a variety of NSF-wide activities.

The IBN Division supports research through the following program clusters:

- **Developmental Mechanisms**
- **Neuroscience**
- **Physiology and Ethology**

### ⓘ For More Information

Write to the Division of Integrative Biology and Neuroscience, National Science Foundation, 4201 Wilson Boulevard, Room 685, Arlington, VA 22230; or contact the division by telephone, 703-292-8420; or visit the IBN home page, http://www.nsf.gov:/bio/ibn/start.htm.

## DEVELOPMENTAL MECHANISMS CLUSTER

This cluster of programs is located within the Division of Integrative Biology and Neuroscience and supports research on the nature, control, and evolution of those processes that comprise the life cycle of organisms. Approaches range from molecular genetic and genomic analysis of developmental processes to the experimental manipulation of whole organisms. Included in this cluster is research on gametogenesis, fertilization, embryogenesis, differentiation, pattern formation, morphogenesis, and areas of development specific to either plants or animals (e.g., self-incompatibility, seed and fruit development). Also included are studies that explore the mechanisms of development in an evolutionary context.

The cluster consists of the following:

1. **Plant and Microbial Developmental Mechanisms**
2. **Animal Developmental Mechanisms**
3. **Evolution of Developmental Mechanisms**

### ⓘ For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/ibn/ibndevelop.htm.

## NEUROSCIENCE CLUSTER

This cluster of programs is located within the Division of Integrative Biology and Neuroscience and supports research on all aspects of nervous system structure, function, and development. Integrative approaches to basic research range from fundamental mechanisms of neuronal function at the molecular and cellular levels to adaptations of the brain for appropriate behavior in particular environments. A major focus is the development and use of a wide diversity of organisms as biological models for understanding fundamental principles of neuroscience. Multidisciplinary collaborative research projects are encouraged to apply different types of research techniques to single-focused problems in neuroscience.

The cluster consists of the following:

1. **Behavioral Neuroscience**
2. **Computational Neuroscience**
3. **Developmental Neuroscience**
4. **Neuroendocrinology**
5. **Neuronal and Glial Mechanisms**
6. **Sensory Systems**

### ⓘ For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/ibn/ibnneuro.htm.

**1. Behavioral Neuroscience—**Focuses on the neural regulation of behavioral events ranging from simple movements to complex adaptive and interactive responses. Molecular, cellular, and systems approaches are used to investigate sensorimotor integration, biological rhythms, and cognitive functions such as attention, spatial representation, and learning and memory. Studies are encouraged that employ a variety of novel techniques to study behavior within an evolutionary and ecological context, including regulation and manipulation of gene expression and genomic analyses, and functional brain imaging.

**2. Computational Neuroscience—**Focuses on the computational functions of neurons, neural circuits, and nervous systems and encourages the development and testing of mathematical or computer models of neural systems. In addition to experimental studies on animals, the activity welcomes theoretical approaches for developing innovative, testable concepts that will clarify and extend current experimental observations in all areas of neuroscience.

**3. Developmental Neuroscience—**Focuses on the development, regeneration, and aging of the nervous system. The use of model systems that elucidate basic mechanisms and principles is encouraged. Current studies include aspects of cell lineage and determination, axonal navigation and cell migration, regulation of gene expression, neuronal morphogenesis and neuron-glia interactions, synaptic specificity and plasticity, cell death, and the relationship of neural developmental mechanisms with learning. Studies typically employ a variety of approaches, including cellular and molecular techniques, genetic and genomic analyses, and the study of development at the systems or behavioral level.

**4. Neuroendocrinology—**Focuses on understanding multifaceted relationships among the central nervous system, hormones, and behavior, especially in relation to environmental factors. This includes how the brain controls endocrine secretion and the effects of steroid and peptide hormones on the brain. Behavioral paradigms and molecular techniques are used to study the basic mechanisms underlying neuroendocrine development and the interaction among physiology, the environment, and gene expression.

**5. Neuronal and Glial Mechanisms—**Focuses on innovative approaches and techniques using novel model systems to explore the cellular and molecular mechanisms of neuronal and glial cell function, including energy metabolism, ion and substrate transport, and synaptic mechanisms. Major thrusts include the genetic and biophysical bases of a membrane's electrical properties, their regulation by intracellular second messengers, and the integration of metabolism and signaling activity by interactions between neurons and glia in both the peripheral and central nervous systems.

**6. Sensory Systems—**Focuses on the mechanisms by which the nervous system acquires, encodes, and processes information about the environment. This includes research on neural processes at the molecular, cellular, systemic, and behavioral levels and psychophysical correlates of sensory neural processes. Topics include sensory transduction; neural coding and integrative mechanisms; and comparative aspects of sensory capabilities, including vision, hearing,

touch, taste, smell, equilibrium, electrosensation, magnetic sensation, and other senses.

## PHYSIOLOGY AND ETHOLOGY CLUSTER

This cluster of programs is located within the Division of Integrative Biology and Neuroscience and supports integrative studies of physiological functions at the genomic,

cellular, systemic, and organismal levels, and animal behavior in both field and laboratory settings.

The cluster consists of the following:

1. **Animal Behavior**
2. **Ecological and Evolutionary Physiology**
3. **Integrative Animal Biology**
4. **Integrative Plant Biology**

### ⓘ For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/ibn/ibnphysio.htm.

**1. Animal Behavior—**Focuses on the mechanisms, development, functions, and evolution of all animal behaviors, studied observationally and experimentally in laboratory and natural settings. Specific areas include behavioral ecology and evolution; nonhuman learning and cognition; behavioral genetics; development of behavior; and behavioral physiology and motivation, including behavioral endocrinology, animal communication, and animal orientation. These areas are neither limiting nor mutually exclusive, and interdisciplinary collaborations and other projects that integrate diverse approaches (including functional genomics) with the study of behavior are particularly encouraged. This program also considers Long-Term Research in Environmental Biology (LTREB) proposals (further information is available at http://www.nsf.gov/bio/progdes/ltreb.htm).

**2. Ecological and Evolutionary Physiology—**Supports research that addresses ecological or evolutionary questions in the areas of morphology, comparative physiology, physiological ecology, and biomechanics of plants, animals, protists, fungi, and bacteria, with emphasis on the study of whole organisms, living or extinct. These studies focus largely on how physiological or morphological mechanisms have evolved and how they may influence evolutionary pathways or interactions between organisms and their biotic or physiochemical environment. The program also considers Doctoral Dissertation Improvement Grants (see program announcement NSF 00-95) and Long-Term Research in Environmental Biology (LTREB) proposals (for further information, see the LTREB web site, http://www.nsf.gov/bio/progdes/ltreb.htm).

**3. Integrative Animal Biology—**Focuses on the basic physiological mechanisms at the molecular, cellular, tissue, organ, and whole-animal levels. The program's encompassing theme is "the whole animal as an integrated system." It includes research on integrative aspects of comparative physiology, functional morphology, endocrinology, epithelial transport, and biomechanics. (Note that studies focusing on the nervous system are supported by the IBN Division's Neuroscience Cluster.) A description of these programs can be found on the cluster's web site, http://www.nsf.gov:/bio/ibn/ibnneuro.htm.

**4. Integrative Plant Biology—**Supports research on plants as functional units, integrating genomic, molecular, biochemical, and biophysical approaches to the understanding of plant form and function. Some examples are whole-plant, tissue, and organ physiology; sensory mechanisms; and hormonal and environmental regulation of plant function. Other examples are plant physiological interactions with pathogens, nitrogen-fixing organisms, mycorrhizae, and other beneficial or pathogenic organisms in the rhizosphere; and interactions with parasites, epiphytes, endophytes, and other commensal

interactions. The emphasis is on understanding the physiological and metabolic basis of plant responses to such interactions. Also supported is research on the physiological and biochemical mechanisms through which plant function adapts to changing environmental conditions.

## DIVISION OF MOLECULAR AND CELLULAR BIOSCIENCES

The Division of Molecular and Cellular Biosciences (MCB) supports research and related activities that contribute to a fundamental understanding of life processes at the molecular, subcellular, and cellular levels.

Investigator-initiated research proposals are considered in the following programs: Biomolecular Structure and Function, Biomolecular Processes, Cell Biology, and Genetics. Programs in the MCB Division also support fundamental studies leading to technological innovation, proposals with substantial computational components, and multidisciplinary and small-group research. Biodiversity and biotechnology are major focal points of MCB. Division programs particularly encourage submission of proposals involving microbial biology, plant biology, theoretical/computational aspects of molecular and cellular studies, molecular evolution, and biomolecular materials. Genomic approaches are encouraged in all areas. During fiscal years 1999 through 2001, the Division coordinated a special BIO-wide competition for Microbial Observatories (see program announcement NSF 01-98). In addition, MCB supports a variety of NSF-wide activities, including Biocomplexity, Life in Extreme Environments, and activities designed to promote the integration of research and education, such as Faculty Early Career Development (CAREER) and Research at Undergraduate Institutions (RUI). Also considered are proposals for limited support of special meetings and workshops and the Undergraduate Mentoring in Environmental Biology (UMEB) activity. UMEB is intended to provide support for talented students to gain research experience in areas of biological science related to the environment and to foster an enriched and culturally diverse research and educational environment.

The MCB Division supports research through the following program clusters:

- **Biomolecular Structure and Function**
- **Biomolecular Processes**
- **Cell Biology**
- **Genetics**

### ⓘ For More Information

Write to the Division of Molecular and Cellular Biosciences, National Science Foundation, 4201 Wilson Boulevard, Room 655, Arlington, VA 22230; or contact the division by telephone, 703-292-8440; or visit the MCB home page, http://www.nsf.gov:/bio/mcb/start.htm.

### BIOMOLECULAR STRUCTURE AND FUNCTION CLUSTER

This cluster of programs is located within the Division of Molecular and Cellular Biosciences and supports research aimed at understanding the structure and function of biological macromolecules, including proteins, nucleic acids, polysaccharides, and lipid assemblies. The research supported by this cluster encompasses a broad range of topics and techniques. The cluster encourages multidisciplinary and innovative efforts between biology and physics, chemistry, mathematics, and computer sciences.

The cluster consists of the following:

1. **Molecular Biochemistry**
2. **Molecular Biophysics**

### For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/mcb/mcbstructure.htm.

**1. Molecular Biochemistry—**Emphasizes the correlation of function with known structures of biological macromolecules and supramolecular structures such as multi-enzyme complexes, membranes, and viruses. Other areas of emphasis include the mechanisms of regulation and catalysis by enzymes and RNA; biochemical reactions involved in bioenergetic processes and photosynthesis; key biochemical processes involved in synthesis and folding of proteins; and the synthesis of other biomolecular materials. Approaches typically include a combination of biochemical, molecular biological, chemical, physical, and genetic techniques. Increasingly a combination of these techniques is being used in an integrated manner to explore the function and mechanisms of action of gene products identified from research in genomics.

**2. Molecular Biophysics—**Supports multidisciplinary research at the interfaces of biology, physics, chemistry, mathematics, and computer science. Emphasis is on research on the structure, dynamics, interactions, and functions of biological macromolecules, including the three-dimensional structures of macromolecules at atomic resolution; assembly and architecture of supramolecular structures (e.g., multienzyme units, viruses, membranes, and contractile proteins); energy transduction; structure and dynamics of photosynthetic reaction centers; and mechanisms of electron and proton transfer in biological systems. Typical approaches and techniques include theory and computation; x-ray diffraction; magnetic resonance; optical spectroscopy; specialized microscopy, such as atomic force; and mass spectrometry. Information from genome sequencing projects and informatics methods are providing new opportunities. For example, bioinformatics methods for parsing genes into protein-domain-encoding regions; methods for automated analysis of protein structures; and computational approaches for comparing new structures with structures available in the protein database are playing an increasing role in molecular biophysics research.

## BIOMOLECULAR PROCESSES CLUSTER

This cluster of programs is located within the Division of Molecular and Cellular Biosciences and supports research on molecular mechanisms by which genetic and metabolic processes occur in plant, animal, and microbial organisms. These processes and related regulatory features are the primary areas of emphasis.

This cluster consists of the following:

1. **Biochemistry of Gene Expression**
2. **Metabolic Biochemistry**

### For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/mcb/mcbprocess.htm.

**1. Biochemistry of Gene Expression—**Supports research using biochemical and molecular biological methods to investigate mechanisms for the replication, expression, transfer, and stability of genetic information, both DNA and RNA. These studies involve primarily in vitro biochemical approaches, including genomics. Gene expression mechanisms are a major focus and include transcription and processing of mRNA regulatory features, including chromatin architecture, RNA stability, and translational mechanisms. Other areas of study include DNA replication, mutation, and repair.

**2. Metabolic Biochemistry—**Supports research on many aspects of the dynamic activities of cells, including characterization of the biochemical pathways and other processes

by which all organisms acquire, transform, and utilize energy from substrates and synthesize new small molecules and macromolecular cell components. Major topics of interest include the diversity of primary and secondary metabolism and mechanisms of metabolic regulation, in response to both internal and external signals. Also of interest are biotransformations of environmentally significant compounds; manipulations of metabolism with practical applications; quantitative and temporal aspects of metabolism; integration and subcellular organization of metabolic processes; and the use of new methods and technologies and approaches, including genomics, to conduct studies of metabolic pathways and networks.

## CELL BIOLOGY CLUSTER

This cluster of programs is located within the Division of Molecular and Cellular Biosciences and supports research on the structure, function, and regulation of plant, animal, and microbial cells. Cluster programs and activities support research that will utilize both traditional and innovative methodologies and encourage multidisciplinary approaches, technique development, modeling, and approaches that exploit genomic information.

The cluster consists of the following:

1. **Cellular Organization**
2. **Signal Transduction and Cellular Regulation**

### ⓘ For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/mcb/mcbcell.htm.

**1. Cellular Organization—**Supports studies of the structure, function, and assembly of cellular elements, such as the cytoskeleton, membranes, organelles, intracellular compartments, intranuclear structures, and extracellular matrix, including cell walls. This encompasses structural and dynamic aspects of cellular and intracellular motility, meiosis and mitosis, and cell shape and polarity, including the mechanisms of endocytosis, exocytosis, and intracellular trafficking of membranes and macromolecules.

**2. Signal Transduction and Cellular Regulation—**Supports the study of intracellular and transmembrane signal transduction mechanisms and functions. These include signal reception; ion channels; second messenger and/or signaling cascades and their interactions; cellular mechanisms of recognition and defense; and the regulation of cell cycle progression.

## GENETICS CLUSTER

This cluster of programs is located within the Division of Molecular and Cellular Biosciences and supports a wide range of studies directed toward answering significant questions of organization, recombination, function, regulation of function, and transmission of heritable information in all organisms, from viruses and micro-organisms to plants and animals. Specific areas include mechanisms of gene regulation, chromosome structure and replication, epigenetic phenomena, DNA repair and recombination, sex determination, genetic interactions between genomes, and molecular evolution and genomics. The methodology used should be appropriate to the questions asked about genetic structure and function. The review process for proposals is organized around the areas described below, although interdisciplinary proposals or proposals that ask genetic questions but use methodology from other scientific disciplines will be co-reviewed in a manner that will ensure effective and fair evaluation of each proposal.

The cluster consists of the following:

1. **Eukaryotic Genetics**
2. **Microbial Genetics**

### ⓘ For More Information

Visit the cluster's web site, http://www.nsf.gov:/bio/mcb/mcbgenetics.htm.

**1. Eukaryotic Genetics—**Supports genetic studies of eukaryotic organisms, with the exception of fungi. Studies of both organelle and nuclear genomes are included, as are studies of viruses of these organisms and parasitic or symbiotic interactions at the genetic level. Epigenetic phenomena, molecular evolution, and genomics are also areas of interest.

**2. Microbial Genetics—**Supports genetic studies of eubacteria, archaebacteria, and fungi, including yeast. Also included are studies of the genetics of bacterial viruses and other infectious agents of bacteria and fungi. Investigations of microbial interactions with other organisms are also considered if the emphasis of the study is on the microbe. Studies on molecular evolution of microbial genes and on genomics are also considered.

## CROSSCUTTING PROGRAMS AND ACTIVITIES

In addition to the programs mentioned in this section, the Directorate for Biological Sciences takes an active role in several crosscutting programs and activities, including for example, the Plant Genome Research Program.

- In fiscal year 1998, NSF initiated the new Plant Genome Research Program. It is part of a national plant genome research initiative established by the Office of Science and Technology Policy (OSTP). The long-term goal of this program is to understand the structure, organization, and function of plant genomes that are important to agriculture, the environment, energy, and health. In fiscal year 1998, the program held two separate competitions (see program announcements NSF 98-30 and NSF 98-52). Results of both competitions are available at http://www.nsf.gov/bio/pubs/awards/genome98.htm.

- In fiscal year 1999, the program continued with the activities supported under program announcement NSF 98-30, and also supported new collaborative research and infrastructure projects under program announcement NSF 99-13. Results of this competition are available at http://www.nsf.gov/bio/pubs/awards/genome99.htm.

- In fiscal year 2000, the program continued with the activities supported under program announcement NSF 98-30, and also supported new collaborative research and infrastructure projects under program announcement NSF 99-171. Results of this competition are available at http://www.nsf.gov/bio/pubs/awards/genome00.htm.

- The fiscal year 2001 competition has been completed. Details about the program are described in program solicitation NSF 00-151. Results of this competition will be posted at http://www.nsf.gov/bio/pubs/awards/genome01.htm when available. In addition, the program will continue to participate in the interagency activities to further develop the national plant genome research initiative as described in the October 1999 and November 2000 National Plant Genome Initiative progress reports, published by OSTP.

The BIO Directorate also provides support for computational biology; research conferences, symposia, and workshops; the purchase of scientific equipment for research purposes; maintenance and improvement of research collections; research directed toward micro-organisms; basic research in conservation and restoration biology; research in biotechnology; research in areas of biosystems analysis and control; and early development of academic faculty as both educators and researchers through such programs as Faculty Early

Career Development. Also provided are active research participation grants for high school students (Research Awards for Minority High School Students), undergraduates (Research Experiences for Undergraduates and Undergraduate Mentoring in Environmental Biology), and faculty from predominantly undergraduate institutions (Research Opportunity Awards); graduate education and research training (Integrative Graduate Education and Research Training); postdoctoral research fellowships; and in selected areas, doctoral dissertation improvement grants.

## For More Information

See the alphabetical listing on the BIO Directorate Programs and Deadlines web site, http://www.nsf.gov:/bio/programs.htm, located on the BIO home page, http://www.nsf.gov/bio/.

Information on many of the programs listed here is available on the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm.

# COMPUTER AND INFORMATION SCIENCE AND ENGINEERING

The National Science Foundation's (NSF's) Directorate for Computer and Information Science and Engineering (CISE) has three goals:

- to enable the United States to hold a position of world leadership in computing, communications, and information science and engineering;
- to promote understanding of the principles and uses of advanced computing, communications, and information systems in service to society; and
- to contribute to universal, transparent, and affordable participation in an information-based society.

To achieve these goals, the CISE Directorate supports investigator-initiated research in all areas of computer and information science and engineering; helps develop and maintain cutting-edge national computing and information infrastructure for research and education in general; and contributes to the education and training of the next generation of computer scientists and engineers.

CISE activities are core to NSF's efforts in information technology, including the Information Technology Research Program. The directorate's activities in fiscal year 2002 (FY 02) encompass broad, thematic, large-scale, and long-term basic computer science research, emphasizing software, human-computer interaction, information management, scalable information infrastructure, high-end computing, and the economic and social implications of information technology. Support will be provided for individual investigator and group research projects and for a limited number of information technology research centers. Complete descriptions of the program and details on proposal submission will be available on the CISE Directorate home page in FY 02.

The CISE Directorate supports programs and activities through the following:

- **Crosscutting Programs and Activities**
- **Division of Computer-Communications Research (C-CR)**
- **Division of Information and Intelligent Systems (IIS)**
- **Division of Advanced Computational Infrastructure and Research (ACIR)**
- **Division of Advanced Networking Infrastructure and Research (ANIR)**
- **Division of Experimental and Integrative Activities (EIA)**

CISE is inherently multidisciplinary, and the directorate strongly encourages collaboration with all NSF-supported disciplines. Several CISE programs—such as Research Infrastructure,

Instrumentation, and Educational Innovations—encompass all fields of computer and information science and engineering and are managed on a cross-divisional basis.

In addition to supporting research, the CISE Directorate provides the general scientific community with access to advanced computing and networking capabilities. Programs such as Partnerships for Advanced Computational Infrastructure give qualified users access to extremely powerful computing resources, train users, and develop the software required for effective use. Networking activities offer and build a national infrastructure for computer and human interaction as well as communication for research and education. In addition, the directorate supports distributed research resources and systems for research and education, and educational development through various activities such as educational infrastructure and educational supplements.

## For More Information

Visit the CISE Directorate home page, http://www.cise.nsf.gov/.

## CROSSCUTTING PROGRAMS AND ACTIVITIES

In addition to the programs mentioned in this section, the CISE Directorate takes an active role in the following crosscutting programs and activities:

- **Information Technology Research**
- **Biocomplexity in the Environment**
- **Learning for the 21st Century**
- **Nanoscale Science and Engineering**

### ⓘ For More Information

Visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm.

## DIVISION OF COMPUTER-COMMUNICATIONS RESEARCH

The Division of Computer-Communications Research (C-CR) supports research in a broad array of areas as well as interdisciplinary research in the context of computer science and engineering. Special areas of emphasis in C-CR include system security and assurance, nano-scale computation, hybrid and embedded systems, mobile computing, and mathematical computation.

The C-CR Division supports the following programs and activities:

1. **Communication Research**
2. **Computer Systems Architecture**
3. **Design Automation**
4. **Numeric, Symbolic, and Geometric Computation**
5. **Operating Systems and Compilers**
6. **Signal Processing Systems**
7. **Software Engineering and Languages**
8. **Theory of Computing**
9. **Hybrid and Embedded Systems**

### ⓘ For More Information

Write to the Division of Computer-Communications Research, National Science Foundation, 4201 Wilson Boulevard, Room 1145, Arlington, VA 22230; or contact the division by telephone, 703-292-8910; or visit the C-CR home page, http://www.cise.nsf.gov/ccr/index.html.

**1. Communication Research (COM)—** Supports research in all aspects of communication science and technology in order to facilitate the efficient representation and transmission of information so as to approach theoretical limits more closely than ever before. This includes efficient representation of information sources; means for densely packed storage and efficient retrieval of information; modern modulation and coding techniques exploiting the temporal and spatial redundancy of channels; resource allocation algorithms working across layers, from physical to presentation; security methods attuned to the requirements of modern e-commerce; and so on. Historically, research in communications was either focused on the so-called physical layer or on the networking layers, with little interplay across this artificial boundary. More recently, societal demands for instant, mobile access to information resources are motivating a more synergistic approach to research in communications. These societal desires are

fed by technological developments like the Internet and high-density storage. They have inspired new research developments while resurrecting older technologies and algorithms, with new twists in order to provide the necessary, high-capacity communication means. It is the goal of this program to sponsor cutting-edge research that will provide the scientific basis for meeting the information requirements of our society in a 5- to 20-year timeframe from the present.

**2. Computer Systems Architecture—** Supports fundamental research on new computing systems. Focus is on new architecture ideas and concepts that will form the basis for solving computing problems likely to arise in the future. Broadly, this covers design, implementation, and evaluation of novel computing structures and technologies. Theoretical and small-scale experimental studies are supported, as are assessments of fault tolerance and performance. Also supported is research on system software, when intimately connected to the architecture or hardware.

Currently, special attention is given to research in the following areas: metrics (benchmarks, new applications, nonperformance metrics); parallelism (including small-scale and mpps); systems of systems (latency reduction, bandwidth increase, processor-in-memory, input/output, interconnects, new device support); small scale MP's, roughly 2-100 nodes (synchronization, communication, protection, memory system structure, reliability, performance metrics, compiler architecture interaction); memory (bandwidth, latency questions, hierarchy management); interconnect (fault tolerance, dynamics of faults and recovery, reliability, quality of service); processor-in-memory (PIM) (single and multiple PIM's, new architectures); input/output (availability, scalable I/O, performance, data stream management, low overhead protection, latency tolerance); single-thread computing (prediction and speculation, architectural support, control implification); multiple-thread computing (multiscalar, dynamic sharing, communication, synchronization, multiple independent processors); protection (nontrusted applications coming in off the Net, security, privacy); and molecular systems (architecture specification, design concepts and tools, simulation of molecular systems).

**3. Design Automation—**Supports basic research in electronic design automation (EDA) and those areas in which Very Large Scale Integration (VLSI) design technology is applicable, such as systems-on-a-chip, embedded systems, and multitechnology (optical, micro-electro-mechanical, etc.) design methods. Research covers all phases of the complete design cycle for integrated circuits and systems, from conception through manufacturing test. Topical areas of VLSI design technology include theoretical foundations, models, algorithms, tools, analysis, synthesis, simulation, validation, and verification; system design methodologies (systems-on-a-chip, multichip, and multitechnology systems); manufacturing (fault models and algorithms for diagnosis and test in digital, analog, and mixed signal designs); and design and system prototyping methods, tools, and environments, especially the information infrastructure aspects.

**4. Numeric, Symbolic, and Geometric Computation (NSGC)—**Supports fundamental research in areas where advanced algorithmic and computational techniques are coupled with mathematical methods of analysis. Specific program areas include computationally oriented numerical analysis; mathematical optimization; symbolic and algebraic computation; computational geometry; computational logic and automated deduction; and computer graphics. The program also supports advanced

computational techniques for simulation of physical processes; design and construction of high-quality mathematical computing software for scientific research; and experimental implementation when it is an integral part of the research. The program also encourages the integration of numeric, symbolic, geometric, and graphic techniques into problem-solving environments to support computational science and engineering. Innovative applications of advanced computational and graphic techniques in science and engineering applications, manufacturing and design, proof support systems, and prototypic and design verification are also welcome.

**5. Operating Systems and Compilers (OSC)—**Supports research on the development, design, evaluation, and implementation of computing systems ranging from operating systems, compilers, and runtime systems to middleware for the integration of heterogeneous systems and information sources. In operating systems and distributed systems, topics of interest include the development of mechanisms and application programming interfaces for uniform access and management of resources in local area networks and wide area networks; middleware infrastructure for building scalable services; resource management for new applications and quality-of-service requirements; security; and electronic commerce. In compilers and runtime systems, the topics of interest include dynamic compilation; techniques that include various models of storage consistency and storage-hierarchy performance; and compiler support for programming on the web.

**6. Signal Processing Systems (SPS)—**Supports fundamental research in the areas of digital signal processing, analog signal processing, and supporting hardware and software systems. Included are one-dimensional digital signal processing (1-D DSP), including (adaptive) filtering and equalization and time-frequency representations; statistical signal and array processing; image and multidimensional digital signal processing, including image analysis, filtering, restoration and enhancement, image and video coding, and vector quantization; and analog signal processing, including analog-to-digital conversion and analog circuits and filters.

Currently, special attention is given to antenna array processing with application to wireless communications systems, especially cellular telephony, personal communications systems, and wireless local area networks; signal compression for reduced data rate with applications to wireless communications systems; scalable/progressive/multiresolution approaches in signal decomposition, compression, and other signal processing techniques to support content analysis; data quality validation; and manufacturing applications (e.g., nondestructive test and evaluation), computed tomography, and synthetic aperture radar (SAR).

**7. Software Engineering and Languages (SEL)—**Supports fundamental research underlying the development and evolution of quality software-based systems. Projects may study or develop methods, processes, tools, or environments, taking a conceptual, experimental, or developmental approach, or may represent innovative work in the theory and design of programming languages, language semantics, and programming environments.

Specific research topics include domain-specific languages for specification and design; constructive approaches to software design and evolution; issues of software modularity and composition; enhancement of confidence and quality; automating stages of software development; distributed and network environment issues, including distributed development and software security; and formal foundations for all

aspects of software engineering and programming languages. Experimental approaches to concept validation are strongly encouraged as a necessary adjunct to conceptually motivated research. Projects contributing to an experimental research infrastructure by providing access to testbeds, software development data, or repositories of software project artifacts will be considered.

**8. Theory of Computing (TOC)—** Supports fundamental research in the following areas:

- Core Theory: Covers computational complexity, cryptography, interactive computation, computational learning theory, parallel and distributed computation, computation on random data, online computation, and reasoning about knowledge.

- Fundamental Algorithms: Includes developing combinatorial, approximation, parallel, online, numerical, geometric, and graph algorithms that transcend application domains.

- Application-Specific Theory: Supports developing models and techniques for solving problems that arise in areas of science and engineering such as molecular biology, communications networks, and computational linguistics.

Also of interest are theoretical developments that have potential impact on experimental or applied areas of computer science research. Investigators are encouraged to pursue strategies that mix theory with experimentation.

**9. Hybrid and Embedded Systems (HES)—**Supports research in scientific principles and technology to revolutionize the design and development of embedded systems for a broad range of applications. Software has enabled increasingly ambitious, often safety-critical systems such as transportation, manufacturing, medical devices and systems, environmental control, and energy management. These include distributed and coordinated embedded systems that demand high levels of autonomy, adaptivity, and component integration, such as multimodal sensing and control. Embedded systems combine interacting elements, including timing, spatial, physical properties, and continuous dynamics of the system to be monitored or controlled; the timing and synchrony properties and resource demands of software that controls the system; and the characteristics and services of the computational platform, both systems software and hardware. A foundation is currently lacking for systematic integration of these elements, particularly for increasingly complex systems.

The goal of the HES Program is to create and unify the foundations for managing interacting physical and computational systems and to supply the technologies needed for building reliable software- and network-enabled embedded systems. The program draws on control theory, modeling, software generation, software systems, and formal verification. Relevant research includes areas such as hybrid (discrete and continuous) modeling and control of physical systems, domain-specific design, programming, and software synthesis approaches for embedded systems; verification technology for checking and certifying correct operation of embedded systems; real-time open systems, middleware, and virtual machine strategies for embedded systems; dynamic scheduling accommodating hard and soft real-time; and program composition approaches for synthesizing software while preserving essential properties.

# DIVISION OF INFORMATION AND INTELLIGENT SYSTEMS

The Division of Information and Intelligent Systems (IIS) supports research that will improve the ability to generate, organize, locate, communicate, and store knowledge using new technologies. IIS recognizes that high-quality content and its accessibility and usability are important benefits provided by new technologies and are complementary to bandwidth and disk space. IIS fundamental research foci include universal access; human language technology; knowledge modeling; scientific collaboratories; robotics; computer vision; data mining; database access technology; human-computer interaction; and embedded intelligent systems. IIS also supports interdisciplinary and interagency activities such as the Digital Libraries and STIMULATE (Speech, Text, Image, and Multimedia Advanced Technology Effort) Initiatives.

The IIS Division supports the following programs and activities:

1. **Digital Society and Technologies**
2. **Human-Computer Interaction**
3. **Information and Data Management**
4. **Knowledge and Cognitive Systems**
5. **Robotics and Human Augmentation**
6. **Special Projects**
7. **Universal Access**

## ⓘ For More Information

Write to the Division of Information and Intelligent Systems, National Science Foundation, 4201 Wilson Boulevard, Room 1115, Arlington, VA 22230; or contact the division by telephone, 703-292-8930; or visit the IIS home page, http://www.cise.nsf.gov/iis/index.html.

**1. Digital Society and Technologies—** Supports research fundamental to the development of new knowledge about the complex processes of adaptation and interchange between society and new information technologies. New theories, models, and technologies are encouraged, as well as empirical maps of the landscape of social and economic change. Research topics include universal participation in a digital society; large-scale social technologies for science, education, and work collaboration and learning; ethical principles in technical design; information privacy and intellectual property in a digital age; and technologies for independence throughout life.

**2. Human-Computer Interaction—** Supports research fundamental to the design of systems that mediate between computers and humans. Topics include universal access; visualization; animation and simulation; interactive computing; human language technology, including speech recognition and natural language understanding; posture- and sound-based interfaces; virtual reality; and multimedia environments.

**3. Information and Data Management—** Supports research fundamental to the design, implementation, development, management, and use of databases; information retrieval; and knowledge-based systems. Topics include data, metadata, information, and knowledge process modeling; information access and interaction; knowledge discovery, data mining, and visualization; and system architecture and implementation. Research areas span web-based systems, multimedia systems, scientific databases, geographic information systems, digital libraries, and other intelligent information systems; efficient data gathering and storage/ archival; information organization,

information flow management, and security/privacy issues; evolutionary systems, change maintenance, and information life-cycle management; heterogeneous systems; and highly scalable, data-intensive, and distributed/mobile information systems.

**4. Knowledge and Cognitive Systems—** Supports research fundamental to the development of machines that behave intelligently. This can be in conjunction with humans (computer-aided machine intelligence) or alone (autonomous intelligent agents). Some of the research involves knowledge representation in machines and studies of cognitive processes, which may be modeled on what we know of human or animal cognition, or which may use approaches different from those in humans and animals. Cognitive activities of interest include multiple types of machine learning, planning, reasoning, decisionmaking, sensory cognition, and linguistic cognition, or combinations of these in intelligent agents. Fundamental research in these areas may have as a goal, for example, the application of integrated design and manufacturing; network management; medical diagnosis; data mining; or intelligent tutoring.

**5. Robotics and Human Augmentation—** Supports research fundamental to the design of machines and systems that implement some characteristics of intelligence and are capable of performing tasks that require generation of mechanical motion. Research topics include theoretical, algorithmic, experimental, and hardware issues on macro-, micro-, and nanoscale, with an emphasis on intelligent sensing and unstructured environments; personal robotics with an emphasis on its human-centered end-use; robotic applications such as systems for surgery, undersea, space, and agriculture; complex sensing, perception, and action; understanding and processing of visual data; representation, reasoning, and planning for complex physical tasks involving temporal and spatial relationships; communication and task sharing between human and machine and among machines; and cooperation among geographically separated robotics resources.

**6. Special Projects—**Supports research, workshops, and other interdisciplinary activities focusing on computing, communications, and the development and use of digital content in a variety of scholarly, social, and work contexts. Special Projects is the managing program for the Digital Libraries Initiative and is global in scope, promoting international collaboration across a wide range of topics related to the expansion of the capabilities and use of the Internet.

**7. Universal Access—**Aims primarily to support research fundamental to empowering people with disabilities so that they are able to participate as first-class citizens in the emerging information society. The program also seeks to advance computer technology so that all people can possess the skills needed to fully harness the power of computing. Focus is on topics such as the development of new models, architectures, and languages that emphasize interface speed and usability by all; the definition of semantic structures for multimedia information to support cross-modal input/output; the development of specific solutions to address the special needs of large disabled communities; and experimental studies to evaluate the success of attempts to provide access in all its varied forms. The word "access" implies the ability to find, manipulate, and use information in an efficient and comprehensive manner.

# DIVISION OF ADVANCED COMPUTATIONAL INFRASTRUCTURE AND RESEARCH

The Division of Advanced Computational Infrastructure and Research (ACIR) provides access to and support of high-end computing infrastructure and research for the national scientific community through its programs.

The ACIR Division supports the following programs and activities:

1. **Advanced Computational Research**
2. **Partnerships for Advanced Computational Infrastructure**
3. **Terascale Computing System**

## ⓘ For More Information

Write to the Division of Advanced Computational Infrastructure and Research, National Science Foundation, 4201 Wilson Boulevard, Room 1122, Arlington, VA 22230; or contact the division by telephone, 703-292-8970; or visit the ACIR home page, http://www.cise.nsf.gov/acir/index.html.

**1. Advanced Computational Research—** Supports a range of enabling technologies needed to advance the state of the art in high performance computing, and brings advanced computing and simulation capabilities to bear on fundamental problems throughout science and engineering. Technologies of particular interest include (a) data handling and visualization; (b) scalable systems; and (3) high-performance algorithms and applications. For details on each of the three focus areas and for specific program information, see program announcement NSF 98-168.

**2. Partnerships for Advanced Computational Infrastructure (PACI)—** Provides the resources and technical expertise to meet the expanding need for high-end computation and information technologies required by the U.S. academic community. The PACI Program supports two partnerships, each consisting of a leading-edge site and a significant number of partners. The two leading-edge sites maintain a variety of high-end computer systems. Together with partners who support smaller versions of these and other computers and experimental systems, they constitute a distributed metacomputing environment that is connected via high-speed networks. PACI sites also participate in the development, application, and testing of the necessary software, tools, and algorithms that contribute to the expansion of this "national grid" of interconnected, high-performance computing systems.

The activities of the partnerships focus on the following: accessibility to a diverse set of advanced and mid-range computer engines, data storage systems, and experimental machine architectures; enabling technologies—through the development of software tools for parallel computation and software for use on the partnerships' widely distributed and architecturally diverse machines and data sources, thus enabling effective use of the partnerships' very large distributed systems; application technologies—engage groups in high-end applications to develop and optimize their discipline-specific codes and software infrastructures, making them available to the program as a whole and to researchers in other areas; education outreach and training—build a growing awareness and understanding of how to use high performance computing and communica-tions resources and broaden the base of participation to help ensure the Nation's

continued world leadership in computational science and engineering.

**3. Terascale Computing System—** Provides a multiteraflop computing system in support of science and engineering research in the United States. NSF bears special responsibility for this national program, which is available for use by the national computational community. The system will be fully available in winter 2001 and is balanced in terms of processor speed, memory, communications, and storage. It is a part of the portfolio of resources provided by the PACI Program, and supplements the capabilities that are available through the PACI partnerships. For further information, see program announcement NSF 00-29.

## DIVISION OF ADVANCED NETWORKING INFRASTRUCTURE AND RESEARCH

The Division of Advanced Networking Infrastructure and Research (ANIR) is concerned with Networking Research (ANR) and Networking Infrastructure (ANI).

The ANIR Division supports the following programs and activities:

1. **Advanced Networking Infrastructure**
2. **Networking Research**
3. **Special Projects**
   - **–Network Centric Middleware Services**
   - **–High Performance Network Connections for Science and Engineering Research**
   - **–Strategic Technologies for the Internet**

### For More Information

Write to the Division of Advanced Networking Infrastructure and Research, National Science Foundation, 4201 Wilson Boulevard, Room 1175, Arlington, VA 22230; or contact the division by telephone, 703-292-8950; or visit the ANIR home page, http://www.cise.nsf.gov/anir/index.html.

**1. Advanced Networking Infrastructure—** Seeks to stimulate, contribute to, and make available for the research and education communities the very latest in high-performance networking capability in both the national and international arenas. The program seeks to enable the use of novel and advanced research applications across all disciplines of science and engineering; coordinate interactions with networking and other disciplines of science; and promote the analysis, improvement, and evolution of the Internet. The focus has shifted from backbone networks to middleware and network services, networked applications, and networking for new participants. Subprograms within this activity include the following:

- Network Centric Middleware Services: Enables those entities who compose the advanced network community, including research universities, government agencies, and industrial units, to collaborate in assembling known and needed pieces of Network Centric Middleware Services. Middleware refers to the software that is common to multiple applications and builds on the network transport services to enable ready development of new applications and network services. By producing a working software distribution, this program will assemble the known pieces and highlight places where new knowledge is needed. Research is also supported on issues relating to this area, to accomplish the above goals. For

specific program information, see program announcement NSF 01-63.

- High Performance Network Connections for Science and Engineering Research: Seeks to provide high performance network connection support for institutions of higher education that are not currently connected to an advanced network, and encourages additional U.S. institutions to established such a high performance Internet connection when such a connection is required to advance an area of scientific research. For example, researchers at an institution that is not yet connected may wish to collaborate on a research project that requires high performance networking with investigators at other institutions. For specific program information, see program announcement NSF 01-73.

- Strategic Technologies for the Internet: Improves the operational or functional capabilities of the Internet and enables related collateral efforts for the benefit of the research and education communities. Areas of support include but are not limited to complex network monitoring, problem detection, and resolution mechanisms; development of automated and advanced network tools, networked applications tools, or network-based middleware; creation of usable and widely deployable networking applications that promote collaborative research and information sharing; and innovative access network technologies. For specific program information, see program announcement NSF 01-90.

**2. Networking Research—**Focuses on the fundamental science and technology needed to facilitate the efficient high-speed transfer of information through networks and distributed systems. Projects funded range from network design and performance evaluation to middleware and software frameworks in support of applications running on top of networks and distributed systems. Projects may also address how networked and distributed systems interact with underlying communications technology and with other related disciplines. Research areas include high-speed, optical, wireless, and mobile networks; traffic control; resource management; quality of service; protocols; multicast; network security, design, and management; performance evaluation; network architectures; network systems; object-oriented frameworks for networks; agent-based networks; multimedia applications; and multiple-access platforms. For specific program information, see program announcement NSF 98-164.

**3. Special Projects—**Differs from the Networking Research Program in that it supports larger and more multidisciplinary projects, specialized hardware and software, or networks for networking systems research. Projects supported by this program focus on networking issues and may include work from other disciplines of computer science and engineering, such as distributed systems, communications, operating systems, databases, software, signal processing, control theory, and devices. Theoretical research activities that address networking issues require small teams of researchers. Experimental research that demonstrates proof of concept for novel networking ideas may range in scope from laboratory experimentation to national collaborations. For specific program information, see program announcement NSF 98-120.

# DIVISION OF EXPERIMENTAL AND INTEGRATIVE ACTIVITIES

The Division of Experimental and Integrative Activities (EIA) supports experimental research, spans several areas, and often involves infrastructure needs. In particular, EIA promotes the development of experimental computer and communications research; furthers the evolution of multidisciplinary research involving the Computer and Information Science and Engineering (CISE) Directorate and other disciplines; contributes to the creation of a diverse personnel pool; carries out exploratory and prototype projects that cross organizational boundaries; operates special international activities; and supports special studies and analyses of issues that affect disciplinary areas supported by the CISE Directorate. In addition, EIA plays a major integrative role in CISE by linking research and education through support for both CISE-specific and NSF-wide activities.

The EIA Division supports the following programs and activities:

1. **CISE Research Resources**
2. **CISE Educational Innovation**
3. **CISE Minority Institutions Infrastructure**
4. **CISE Postdoctoral Research Associates**
5. **CISE Research Infrastructure**
6. **Biological Information Technology Systems**
7. **Combined Research-Curriculum Development**
8. **Digital Government**
9. **Quantum and Biologically Inspired Computing**
10. **Integrative Graduate Education and Research Training**
11. **Major Research Instrumentation**
12. **Next Generation Software**
13. **NSF-CONACyT Collaborative Research Opportunities**
14. **NSF-CNPq Collaborative Research Opportunities**
15. **Research Experiences for Undergraduates**
16. **Special Projects**

## ⓘ For More Information

Write to the Division of Experimental and Integrative Activities, National Science Foundation, 4201 Wilson Boulevard, Room 1160, Arlington, VA 22230; or contact the division by telephone, 703-292-8980; or visit the EIA home page, http://www.cise.nsf.gov/eia/index.html.

**1. CISE Research Resources (CISE-RR)—**Is designed to increase the capability and capacity to carry out basic research in information technology at U.S. institutions. The program supports the acquisition and/or development of advanced resources for research and integrated research/education activities. Resources may include research equipment, instrumentation, software, data repositories, or services. Resources supported under this program are those generally not supported by other programs because of cost, complexity, level of shared use, or other reasons. CISE-RR consists of the following three elements:

- CISE Instrumentation: Supports grants for the acquisition and purchase of research resources in areas of science or engineering supported in the CISE Directorate. These research resources should be required for at least two research projects and no more than four research projects.

- Collaborative Research Resources: Supports grants to support the establishment, enhancement, and operation of major resources for multi-

investigator, synergistic or integrated research/education. Awards may be for activities solely within a single academic department, activities drawing from several departments in a single institution, or activities spanning several different institutions.

- Distributed Research Resources: Supports grants for the establishment and maintenance of unique, geographically distributed resources that, once established, can be accessed remotely by CISE researchers around the country.

**2. CISE Educational Innovation—** Supports innovative educational activities at the undergraduate level in computer and information science and engineering that transfer research results into the undergraduate curriculum. Projects supported are expected to show promise as a national model of excellence by acting as a prototype for use by a broader segment of the CISE community. Proposals may address a variety of educational activities, including the development of courses, instructional technologies, software, and other educational materials. A related program, Combined Research and Curriculum Development, in cooperation with the Engineering Directorate, supports multidisciplinary projects in upper-level undergraduate and introductory graduate-level curricula. For specific program information, see program announcement NSF 00-33.

**3. CISE Minority Institutions Infrastructure—**Provides awards to aid efforts that might significantly expand the numbers of minority students attracted to and retained in computer and information science and engineering disciplines. Eligible institutions must be minority institutions (defined by significant percentages of minority students). The program considers a variety of activities, including research programs involving minority students, curriculum development projects, mentoring, and outreach. Both 1-year planning grants and continuing grants of up to 5 years in duration are awarded. Significant matching for the latter (usually 25 percent) is expected. For specific program information, see program announcement NSF 96-15.

**4. CISE Postdoctoral Research Associates—**Aims to increase the expertise in experimental computer science and engineering by providing opportunities to work in established laboratories performing experimental research in computer science and engineering. Through these awards, recent Ph.D.'s are able to broaden their knowledge and experience and prepare for significant research careers on the frontiers of experimental computer science. For specific program information, see program announcement 97-169.

**5. CISE Research Infrastructure—** Provides support for the establishment, enhancement, and operation of major experimental facilities for all CISE research areas. Projects supported usually involve several individual projects with synergy among their research activities. CISE area Ph.D. degree-granting departments or partnerships with at least one such partner are eligible. Outreach to underrepresented groups is another program goal. For specific program information, see program announcement NSF 00-5.

**6. Biological Information Technology Systems (BITS)—**Supports high-risk/high-return research at the interface of biology and information technology. Biological systems have enormous capabilities as powerful and agile control systems for robotic and regulatory systems and for pattern recognition, adaptability, information storage, retrieval and processing, sensor fusion, and other information-handling

tasks. Biology often performs orders of magnitude better than systems based on today's silicon device technologies. Determining what needs to be and what can be learned about information processing in biological systems should lead to important new information systems (algorithms, software, and systems) and technologies (computer platforms, sensors, robotic devices, etc.). The initial phase of this program will focus on developing computational models and theories for the information-processing mechanisms encountered in biological systems that will lead to new information technology systems and hardware platforms. While these new information technology systems will not necessarily or exclusively be implemented in biological matter, the program will emphasize hybrid (bio-silical) systems, particularly as a means for experimenting with and validating new theories of biological information technologies and systems.

**7. Combined Research-Curriculum Development (CRCD)—**Emphasizes the need to incorporate exciting research advances in important technological areas into the upper-level undergraduate and graduate engineering curricula. A major objective of the program, which is jointly supported by the CISE Directorate and the Engineering Directorate, is to stimulate faculty researchers to place renewed value on quality education and curriculum innovation in the context that education and research are of equal value and complementary parts of an integrated whole.

Each project supported by the CRCD Program focuses on a particular topic that is of importance to industry and to the Nation in areas supported by both Directorates. In addition, each CRCD project contains five major components: research, curriculum development, a team of participants (faculty and students), project evaluation plans, and cost sharing of at least 25 percent. For specific program information, see program announcement NSF 00-66.

**8. Digital Government—**Aims to build a research domain of problems that intersect the traditional CISE research communities with the mid- to long-term research, development, and experimental deployment needs of the Federal information service communities. It accomplishes this by supporting projects that innovatively, effectively, and broadly address potential improvement of agency, interagency, and intergovernmental operations and government-citizen interaction. The Federal Government is a major user of information technologies, a collector and maintainer of very large data sets, and a provider of critical, often unique information services to individuals, states, businesses, and other customers. Still, most Federal agencies are struggling with the creation of a strategic vision and an operational philosophy for information technologies. For specific program information, see program announcement NSF 99-103.

**9. Quantum and Biologically Inspired Computing (QUBIC)—**Supports interdisciplinary research to improve the fundamental capabilities of computer science by incorporating insights from either biological systems or quantum foundations or both. To achieve this improvement, there needs to be fundamental research into the unification of information science across computer science, physics, biology, and engineering. Expanding research efforts in interdisciplinary areas at the interface of information science and technology with the fields of biology, chemistry, engineering, physics, and computer science will lead to better understanding in all areas of science. This will increase the ability to develop future information technologies that are very critical to the economy and society at the national and international level. Priority is given to group proposals that represent multiple disciplines, although single-

investigator proposals that are cross-disciplinary are also considered.

**10. Integrative Graduate Education and Research Training (IGERT)—**Seeks to enable the development of innovative, research-based graduate education and training activities that will produce a diverse group of new scientists and engineers who are well prepared for a broad spectrum of career opportunities. Projects supported must be based on a multidisciplinary research theme and organized around a diverse group of investigators from Ph.D.-granting institutions in the United States with appropriate research and teaching interests and expertise. For further information, see program solicitation NSF 00-78, or visit the IGERT web site, http://www.nsf.gov/home/crssprgm/igert/start.htm.

**11. Major Research Instrumentation (MRI)—**Supports projects that have one primary research focus and whose infrastructure requirement is too costly for other programs. All institutions are eligible, with a limit of two proposals from each institution per year. Matching at the 30-percent level is expected. For further information, see program solicitation NSF 99-168, or visit the MRI home page, http://www.nsf.gov/od/oia/programs/mri/start.htm.

**12. Next Generation Software (NGS)—** The overall thrusts of NGS are research and development for new software technologies integrated across a system's architectural layers; support for the design and the operation cycle of applications, computing, and communications systems; and delivering quality of service (QoS). For specific program information, see program announcement NSF 00-134.

NGS fosters multidisciplinary software research under two components:

- Technology for Performance Engineered Systems (TPES): Supports research for methods and tools leading to the development of performance frameworks for modeling, measurement, analysis, evaluation, and prediction of performance of complex computing and communications systems, and of the applications executing on such systems.

- Complex Application Design and Support Systems (CADSS): Supports research on novel software for the development and runtime support of complex applications executing on complex computing platforms. This includes programming models, new compiler and runtime technology, application composition environments, and debugging tools. CADSS-fostered technology breaks down traditional barriers in existing software components in the application development, support, and runtime layers, and will leverage TPES-developed technology for delivering QoS.

**13. NSF-CONACyT Collaborative Research Opportunities—**Supports, jointly between NSF and the Consejo Nacional de Ciencia y Tecnologia (CONACyT) (National Council of Science and Technology Research) of Mexico, efforts in international cooperative research and research infrastructure in computer science, information systems, computer engineering, and engineering research, including environment and manufacturing, civil, chemical, electrical, mechanical, and biomedical systems. Proposals from Mexican researchers and research institutions are selected and administered by CONACyT and are subject to the regulations of the Program for the Support of Science in Mexico. Proposals to NSF from researchers at institutions in the United States are subject to standard NSF review procedures and will be processed by the CISE Directorate and by NSF's Directorate

for Engineering. Proposals are accepted in all areas usually covered by the Directorate. For specific program information, see program announcement NSF 96-145.

**14. NSF-CNPq Collaborative Research Opportunities—**Supports, jointly between NSF and CNPq-Conselho Nacional de Desenvolvimento Cientifico e Tecnologico da Pesquisas (National Council of Scientific and Technological Research) of Brazil, new efforts in international cooperative research in any CISE-related area where the efforts are likely to produce positive, complementary, and synergistic effects.

The initiative seeks to advance scientific and engineering knowledge in areas of interest to the CISE Directorate through joint research efforts by investigators who have complementary talents and interests. The initiative capitalizes on the international character of modern scientific research and the ability to conduct collaborative research from a distance through the support of computer network infrastructures.

Proposals from Brazilian researchers and research institutions are selected and administered by CNPq's ProTem Office (Programa Tematico Multiinstitucional em Ciencia da Computacao) and are subject to the standards for submission and review of that organization. Proposals to NSF from researchers at institutions in the United States will be subject to standard NSF review procedures outlined in the NSF *Grant Proposal Guide* (see http://www.nsf.gov/cgi-bin/getpub?gpg for latest version) and will be processed by the CISE Directorate. For specific program information, see program announcement NSF 98-139; or contact Larry Brandt, program director, by telephone, 703-292-8980, or by e-mail, lbrandt@nsf.gov; or visit the NSF-CNPq web site, http://www.cnpq.br.

**15. Research Experiences for Undergraduates (REU)—**Provides opportunities for undergraduate students to experience hands-on participation in research and related scholarly activities. Active research experience is one of the most effective techniques for attracting talented undergraduates to and retaining them in careers in mathematics, science, and engineering. The REU Program, a Foundation-wide effort, is designed to help meet this need. REU has two components: one supports sites for several students; the other supplements awards to existing research grants for one or two students. For more information on REU, see program announcement NSF 01-121; or refer to the "REU Points of Contact at NSF" list on the REU web site, http://www.nsf.gov/home/crssprgm/reu/start.htm.

**16. Special Projects—**Supports activities to expand opportunities for women, minorities, and persons with disabilities in computer and information science and engineering and for special workshops, symposia, and analytical studies of interest to the CISE Directorate. Potential proposers are strongly encouraged to contact a program director to discuss their project ideas before submitting a proposal.

# EDUCATION AND HUMAN RESOURCES

The Directorate for Education and Human Resources (EHR) is responsible for the health and continued vitality of the Nation's science, mathematics, engineering, and technology education and for providing leadership in the effort to improve education in these areas.

The EHR Directorate supports programs and activities through the following:

- **Division of Educational System Reform (ESR)**
- **Division of Elementary, Secondary, and Informal Education (ESIE)**
- **Division of Graduate Education (DGE)**
- **Division of Human Resource Development (HRD)**
- **Division of Research, Evaluation, and Communication (REC)**
- **Division of Undergraduate Education (DUE)**
- **Experimental Program to Stimulate Competitive Research (EPSCoR)**

## ⓘ For More Information

Visit the EHR Directorate home page, http://www.ehr.nsf.gov/.

### Math and Science Partnerships Initiative

The Foundation will develop and implement a new programmatic activity for fiscal year 2002 called the Math and Science Partnerships Initiative (MSPI). MSPI will provide funds for States and local school districts to join with institutions of higher education, particularly with their departments of mathematics, science, and engineering, in strengthening mathematics and science education. It is designed to mobilize the mathematicians, scientists, and engineers of higher education to be part of the solution to improve K–12 education, to help raise mathematics and science standards; provide mathematics and science training for teachers; and create innovative ways to reach underserved schools and students. It emphasizes the need to ensure that all students have the opportunity to perform to high standards using effective, research-based approaches; improve teacher quality; and insist on accountability for student performance. One of its key objectives is to eliminate performance gaps between majority and minority and disadvantaged students.

Once available, more information on the upcoming MSPI will be available on the EHR Directorate's home page, http://www.ehr.nsf.gov.

# DIVISION OF EDUCATIONAL SYSTEM REFORM

The Division of Educational System Reform (ESR) manages a portfolio of programs that encourage and facilitate coordinated approaches to systemic, standards-based reform of science, mathematics, and technology (SMT) education.

Systemic reform relies on partnerships to identify needs, articulate visions, and develop goals, strategies, and activities for improvement of targeted areas. Although each systemic initiative is unique in its approach, all must begin as a collaborative effort among individuals and organizations that are committed to requiring high expectations for all students through challenging educational opportunities. Systemic initiatives catalyze change and cultivate coordination within cities, States, rural areas, school systems, and other organizations involved with education. They result in a comprehensive impact on curriculum (inclusive of content, instruction, and assessment), policy, professional development, convergence of intellectual and fiscal resources, broad-based stakeholder support, and student performance.

The proposing organization develops a single plan of reform that must delineate the curriculum, professional development, and assessment components to ensure a transition to a high-quality, standards-based SMT education for all students. Awardees enter into cooperative agreements with NSF, specifying accountability for reaching the goals of a reform plan that must result in demonstrable and wide-ranging improvements in student achievement.

The ESR Division supports improvement in K–12 SMT education through the following programs and activities:

1. **Urban Systemic Program**
2. **Rural Systemic Initiatives**

There will be no competitions for either the Urban Systemic Program or the Rural Systemic Initiatives in fiscal year 2002.

## ⓘ For More Information

Write to the Division of Educational System Reform, National Science Foundation, 4201 Wilson Boulevard, Room 875, Arlington, VA 22230; or contact the division by telephone, 703-292-8690; or visit the ESR home page, http://www.ehr.nsf.gov/EHR/ESR/index.htm.

**1. Urban Systemic Program (USP)—** Urban school systems enroll more than half of all public school students in the United States. Although progress is being made in student achievement, there is a continuing disparity between the academic performance of urban students in science and mathematics and their counterparts in suburban schools. This disparity has been linked to a number of factors, including uneven allocation of resources; lack of highly qualified and experienced teachers; low enrollment in advanced courses; inadequate curricular materials; lack of good equipment and facilities; and few role models for students. Nevertheless, as measured by State and local criteria and norm-referenced tests, student achievement in science and mathematics showed significant gains, particularly at the elementary level. USP represents an effort to help urban school systems make deeper inroads into overcoming these factors while sustaining gains and advancing efforts through the high school level to improve student achievement.

**Eligibility Requirements for USP**

To be eligible, school districts must serve a central city and have a student population of at least 20,000. It is presumed that proposals for USP will originate from the Office of the Superintendent or other official who is designated as the Chief School Officer. Proposals must meet a cost-share requirement of 20 percent of the proposed budget request. Importantly, school districts seeking USP support must show an established infrastructure for change; demonstrate that standards-based reform is significantly under way in the school system; and possess the ability to advance standards-based reform into full-scale implementation.

**2. Rural Systemic Initiatives (RSI)—** Seeks to promote systemic improvement in science, mathematics, and technology (SMT) education for students in rural and economically disadvantaged regions of the Nation. RSI is particularly concerned with those students who have been underserved by NSF programs. RSI seeks to ensure sustainability of improvements by encouraging community development activities in conjunction with instructional, policy, and resource restructuring.

Students in rural areas, particularly those characterized by high and persistent poverty, typically receive much less instruction in science and mathematics than do students in some suburban or urban classrooms. Moreover, societal conditions can be barriers that keep these students from achieving. Taken together, these circumstances negatively affect a child's chances of pursuing a postsecondary degree or career that could provide a better quality of life.

The premise of RSI is that a variety of educational, economic, and social factors must be aligned to significantly affect the achievement levels of students in disadvantaged circumstances. Therefore, RSI proposals must be submitted on behalf of consortia formed to address curriculum reform; teacher preservice and in-service education; policy restructuring, assessment, and implementation of national standards; and the economic and social well-being of the targeted regions.

The RSI program supports the following three categories of awards:

- **Development Awards—**The complexity of systemic educational reform generally requires discussion and planning. In addition, consensus-building is essential for successful implementation of a reform agenda. Development awards will be made to establish regional coalitions that have articulated visions and goals for educational improvement. They will typically support a self-study of the region; the development of baseline data; an in-depth study of proposed activities coupled with their feasibility in this context; articulation of implementation strategies; and determination of financial commitment of the relevant partners.

- **Implementation Awards—**While the establishment of regional coalitions is a key component, the primary goal of RSI is the successful and sustainable improvement of SMT education at the K–12 levels in rural, economically disadvantaged, remote, and sparsely populated areas. Proposers must have demonstrated readiness to achieve systemic educational reform through comprehensive planning that has (1) produced a regional vision for SMT education; (2) resulted in commitment to policy, fiscal, and instructional practice reforms on the part of the participating districts; (3) identified strengths and weaknesses in current programs; (4) secured local, State, and national resources, both public and private, to promote necessary change; and (5)

focused on needed State and local policy changes to expedite reform.

- **Tribal Colleges and Universities Component—**In response to Presidential Executive Order 13021, White House Initiative for Tribal Colleges and Universities, the RSI Program established a separate competition for, and accepts proposals from, tribal colleges and universities (TCU's) to promote systemic reform in K–12 schools within their service areas. Activities funded under the TCU component are the same as those for the RSI Development or Implementation awards, but typically the TCU awards target fewer school districts in their consortia.

**Eligibility Requirements for RSI**

Eligible school districts are those designated as "rural" or "small town" according to the U.S. Department of Education, National Center for Education Statistics, and in which greater than 30 percent of the school-age children are living in poverty. Proposing consortia should include representatives from State and local education agencies and schools and may include community colleges, business and industry, health and human service agencies, economic development agencies, private foundations, and 4-year colleges and universities.

## DIVISION OF ELEMENTARY, SECONDARY, AND INFORMAL EDUCATION

Programs in the Division of Elementary, Secondary, and Informal Education (ESIE) work together to provide students, grades preK through 12, with access to quality science, mathematics, and technology (SMT) learning opportunities and increase scientific literacy for citizens of all ages. ESIE's education efforts are designed to promote the success of all students, regardless of their background, ability, or future education plans.

ESIE achieves its goals by supporting the development and implementation of high-quality instructional materials, as well as strategies to strengthen teacher competency in SMT content and pedagogy; to prepare students for transition from secondary school to higher education levels and the workplace; and to provide stimulating learning environments outside of school. Essential to achieving these goals are ESIE's efforts to rebuild and diversify the national infrastructure for SMT education; engage parents in their children's education; and promote the use of learning technologies for increasing access to quality education and addressing the varied learning styles of students. ESIE projects are built on collaboration among K–12, higher education, informal science, and business sectors, as well as meaningful partnerships of scientific and technical practitioners, SMT educators, and education administrators.

ESIE supports the following programs and activities:

1. **Teacher Enhancement**
2. **Centers for Learning and Teaching**
3. **Instructional Materials and Assessment Development**
4. **Informal Science Education**
5. **NSF After-School Centers for Exploration and New Discovery**
6. **Presidential Awards for Excellence in Mathematics and Science Teaching**
7. **Advanced Technological Education**

### ⓘ For More Information

Write to the Division of Elementary, Secondary, and Informal Education,

National Science Foundation, 4201 Wilson Boulevard, Room 885, Arlington, VA 22230; or contact ESIE by telephone, 703-292-8620, or by e-mail, ehr-esi-info@nsf.gov; or visit the ESIE home page, http://www.ehr.nsf.gov/ehr/esie/.

**1. Teacher Enhancement (TE)—**Supports professional development projects that promote strong conceptual understanding and instructional and leadership skills. These projects help build a supportive school culture that empowers teachers to engage all students in rich and challenging science, mathematics, and technology (SMT) education. The TE Program supports the following types of projects:

- **Local Systemic Change—**Supports school districts and their partners in reforming K–12 science and/or mathematics education. Local Systemic Change projects emphasize strategies that will lead to successful implementation of national standards for content, teaching, assessment, programs, and systems. Projects include comprehensive or full-scale reform efforts and pilot efforts for building a foundation for reform through exploration of exemplary instructional materials, and for developing district leadership in SMT education.

- **Teacher Retention and Renewal—**Supports efforts to develop and retain an effective SMT instructional workforce. Projects are expected to develop cadres of teacher leaders within districts who can (a) serve as mentors to novice SMT teachers during their induction years and (b) act as change agents for implementing SMT programs that model standards-based teaching and provide professional development opportunities for peers.

- **Mathematics and Science Courses for Improving Teacher Qualifications—**Creates pilot courses for teachers who are currently (a) SMT teachers responsible for courses out of their field of certification; (b) SMT teachers with inadequate disciplinary backgrounds; and (c) SMT teachers seeking to provide instruction at another grade level. Courses should build on current research on teaching and learning and include instruments to assess participant learning and provide evidence of effectiveness.

- **Professional Development Materials—**Develops training materials for teachers and instructional SMT leaders in grades preK through 12. These materials address needs identified in major SMT education reform efforts, including enhancement of teachers' understanding; the adoption and implementation of standards-based teaching practices; and the use of state-of-the-art instructional materials, assessment strategies, and educational technologies.

- **Technology in Support of Professional Development—**Anticipates changes in the access to and capabilities of learning technologies. Projects develop technological tools to improve teaching and support instructional delivery; expand access to resources; and provide opportunities for interaction among education stakeholders (e.g., teachers, teacher educators, scientists, mathematicians, engineers, technologists, and informal science educators).

**Eligibility Requirements for TE**

The TE Program has special eligibility requirements beyond the standard NSF requirements. For more information, see program solicitation and guidelines NSF 01-60.

**2. Centers for Learning and Teaching (CLT)—**Addresses national issues critical to

the K–12 instructional workforce through partnerships forged between the higher education and K–12 sectors. Supported centers must respond to each of the following goals: (a) increase the number of new and current K–12 educators who are prepared to facilitate standards-based science, mathematics, and technology (SMT) instruction; (b) rebuild and diversify the national infrastructure for K–16 education in science, mathematics, engineering, and technology; and (c) provide substantive opportunities for research on teaching and learning, education reform policies, and outcomes of standards-based reform in science and mathematics. Emphasis is placed on educating future generations of SMT teachers and professionals in content, instructional practices, assessment, research, evaluation, curriculum development, and informal education.

**Eligibility Requirements for CLT**

The CLT Program has special eligibility requirements beyond the standard NSF requirements. For more information, see program solicitation NSF 00-148.

**3. Instructional Materials and Assessment Development (IMAD)—**Supports the development of materials and assessment strategies that are aligned with national standards and promotes improvement of science, mathematics, and technology (SMT) instruction at the preK through 12 levels. These materials should enable students to acquire sophisticated content knowledge, higher-order thinking abilities, and problem-solving skills.

IMAD-supported materials are designed for the success of all students regardless of their background, ability, or future education plans. They should promote students' positive attitudes toward SMT disciplines and students' positive perception of themselves as learners. By incorporating investigative, hands-on science and mathematics activities, the materials facilitate changes in the basic delivery of classroom instruction. Although demonstration models may be funded, projects are expected to be national in scope so that upon completion, the materials will be ready for use by teachers and students across the nation.

**Eligibility Requirements for IMAD**

The IMAD Program has special eligibility requirements beyond the standard NSF requirements. For more information, see program solicitation and guidelines NSF 01-60.

**4. Informal Science Education (ISE)—** Provides rich and stimulating opportunities for informal learner's that are designed to deepen their appreciation of science and technology and their understanding of the impact science and technology has on today's society. Major categories of projects include exhibits (in museums, science centers, zoological parks, arboreta, aquaria, and botanical gardens), media, and community-based programs. Projects generally develop materials and programs that reach large audiences and have the potential for significant regional or national impact.

The ISE Program promotes collaborative efforts, especially when such efforts bridge the informal and formal education communities. These collaborations allow partners to combine their resources and expertise to develop more effective strategies for reaching diverse target audiences, particularly underrepresented populations (e.g., minorities, women) and underserved areas (e.g., rural, inner city). ISE also strives to engage parents and other adults as proponents for quality SMT education.

**Eligibility Requirements for ISE**

The ISE Program has special eligibility requirements beyond the standard NSF requirements. For more information, see program solicitation and guidelines NSF 01-60.

**5. NSF After-School Centers for Exploration and New Discovery (ASCEND)—**Provides unique opportunities for middle and high school students to explore science, mathematics, and engineering in creative after-school and weekend programs. Projects are designed to interest youth in ongoing scientific discovery, as well as careers in science, mathematics, engineering, and technology.

**Eligibility Requirements for ASCEND**

The ASCEND Program has special eligibility requirements beyond the standard NSF requirements. For more information, see program solicitation and guidelines NSF 01-60.

**6. Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST)—**The PAEMST Program is operated by NSF on behalf of the White House. It is the Nation's highest honor for K–12 science and mathematics teachers. Since its inception in 1983, PAEMST has provided national recognition for nearly 3,000 outstanding elementary and secondary teachers of mathematics and science in the 50 States and U.S. territories. Awardees participate in a recognition program in Washington, DC, where they are honored by the White House, NSF, other Federal agencies, the National Academy of Sciences, the business community, and various professional organizations. Awardees have received $7,500 from NSF to improve science or mathematics education in their schools and districts.

**Eligibility Requirements for PAEMST**

The PAEMST Program has special eligibility requirements beyond the standard NSF requirements. For complete information, visit the PAEMST web site, http://www.ehr.nsf.gov/pres_awards/. .

**7. Advanced Technological Education (ATE)—**Is managed jointly by the ESIE Division and the Division of Undergraduate Education. ATE promotes improvement in the education of technicians in science- and engineering-related fields at the undergraduate and secondary school levels. It particularly targets 2-year colleges and encourages collaboration among 2-year colleges, 4-year colleges, universities, secondary schools, business, industry, and government. Proposals are solicited in the following three major tracks:

- **Projects—**Activities may include the design and implementation of new courses, laboratories, and educational materials; the adaptation and implementation of exemplary curricula and programs in new educational settings; the preparation and professional development of college faculty and secondary school teachers; internships and field experiences for students, faculty, and teachers; or national conferences, workshops, and similar activities focusing on issues in technological education.

- **Centers—**ATE Centers are comprehensive national or regional resources that provide models and leadership for other projects and act as clearinghouses for educational materials and methods. National Centers of Excellence engage in the full range of activities described above for projects. Regional Centers for manufacturing or information technology education pursue comprehensive approaches focusing on reforming academic programs, departments, and systems to produce a

departments, and systems to produce a highly qualified workforce to meet industry's needs within a particular geographic region.

- **Articulation Partnerships—**These projects focus on enhancing either of two important educational pathways for students between 2-year colleges and 4-year colleges and universities. One type of Articulation Partnership focuses on strengthening the science, mathematics, and technology preparation of prospective K–12 teachers who are enrolled in preprofessional programs at 2-year colleges. The other type of Articulation Partnership targets 2-year college programs for students to continue their education in 4-year science, mathematics, engineering, and technology programs, especially programs that have a strong technological basis.

Proposals in all three tracks must show evidence of a coherent vision of technological education—a vision that recognizes the needs of the modern workplace, of students as lifelong learners, and for articulation of educational programs at different levels.

### ⓘ For More Information

Visit the ATE Program web site, http://www.ehr.nsf.gov/EHR/DUE/programs/ate/.

## DIVISION OF GRADUATE EDUCATION

The Division of Graduate Education (DGE) provides support for graduate students, postdoctoral fellows, and graduate education programs to ensure the strength, diversity, and vitality of the science and engineering workforce in the United States. DGE aims to enhance the flexibility and appropriateness of graduate programs at various levels in order to maintain the preeminence of American science, mathematics, and engineering and to strengthen the U.S. economy. Activities supported by the division fortify the links between higher education and K–12 education; recognize and support a diverse pool of outstanding individuals in their pursuit of advanced science, mathematics, engineering, and technology education; and support innovative models of graduate education.

DGE supports research and education through the following programs and activities:

1. **Graduate Research Fellowships (GRF)**
2. **Graduate Teaching Fellowships in K–12 Education (GK–12)**
3. **Integrative Graduate Education and Research Traineeships (IGERT)**
4. **NSF-NATO Postdoctoral Fellowships in Science and Engineering (NATO)**
5. **Travel Grants for NATO Advanced Study Institutes (ASI)**

### ⓘ For More Information

Write to the Division of Graduate Education, National Science Foundation, 4201 Wilson Boulevard, Room 907, Arlington, VA 22230; or contact the division by telephone, 703-292-8630. For information, including program announcements and application forms, visit the DGE home page, http://www.ehr.nsf.gov/dge.

**1. Graduate Research Fellowships (GRF)—**Promotes the strength and diversity of the Nation's scientific and engineering base, and offers recognition and 3 years of support for advanced study to

approximately 900 outstanding graduate students annually in all fields of science, mathematics, and engineering supported by NSF. For awards that will be used in academic year 2001–2002, the stipend for each fellow will be $18,000 for a 12-month tenure, and an annual cost-of-education allowance of $10,500 will be made available to the awardee's institution for each year of tenure, in lieu of tuition and fees.

**Eligibility Requirements for GRF**

To be eligible for this nationwide merit competition, an individual must be a citizen, national, or permanent resident of the United States, and at or near the beginning of graduate study.

**For More Information**

For fiscal year 2002 applications, write to Oak Ridge Associated Universities (ORAU), NSF Graduate Research Fellowship Program, P.O. Box 3010, Oak Ridge, TN 37831-3010; or contact ORAU by telephone, 865-241-4300; or by e-mail, nsfgrfp@orau.gov.

Individuals are expected to apply through FastLane at http://www.fastlane.nsf.gov. Application forms and instructions are also available on the GRF web site, http://www.nsf.gov/grfp.

**2. Graduate Teaching Fellowships in K–12 Education (GK–12)—**In order to strengthen K–12 science and mathematics education, provide pedagogical training and experience for graduate students, and enhance links between K–12 and higher education levels, NSF initiated the GK–12 Program in 1999. GK–12 projects support graduate and advanced undergraduate science, mathematics, engineering, and technology (SMET) students as content resources for K–12 teachers. These Fellows assist teachers in the science and mathematics content of their teaching; demonstrate key science and mathematics concepts; and gain pedagogical skills necessary at all education levels. The activity links the acknowledged excellence of U.S. graduate education with the excitement and critical needs of K–12 learning and teaching, and promotes interest in teaching and learning practices among graduate level institutions.

Proposals may be submitted only by academic institutions that grant masters or doctoral degrees in SMET fields. GK–12 fellows, selected by awardee institutions, must be citizens, nationals, or permanent residents of the United States. They must be graduate students enrolled in SMET programs or advanced undergraduate SMET majors who have demonstrated a strong proficiency in mathematics and science.

**For More Information**

Visit the GK–12 Program web site, http://www.nsf.gov/home/crssprgm/gk12/.

**3. Integrative Graduate Education and Research Traineeships (IGERT)—**NSF places high priority on the preparation of Ph.D.'s who are equipped with the multidisciplinary background and the technical, professional, and personal skills essential to address the career demands of the future. To meet these needs, NSF created IGERT, an agency-wide graduate education program. Unlike Graduate Fellowships, for which individuals apply, IGERT considers only proposals from institutions that offer doctoral degrees.

The primary goal of the IGERT Program is to enable the development of innovative graduate education activities that are research-based and that will produce scientists and engineers who are well prepared for a broad spectrum of career opportunities. IGERT integrates research and education with emphasis on

experimentation to yield a variety of new models for a paradigm shift in graduate education. Projects supported should incorporate the following features:

- a comprehensive, doctorate-level multidisciplinary research theme that serves as the foundation for graduate education activities;
- activities that integrate the multidisciplinary research theme with innovative educational opportunities, including training in the responsible conduct of research and interactions between students and faculty;
- an educational environment that exposes students to state-of-the-art research instrumentation and methodologies;
- an institutional strategy and operation plan for student recruitment, with special consideration for efforts aimed at members of groups underrepresented in science and engineering, to ensure preparation of a diverse science and engineering workforce; and
- a well-defined strategy for assessment of project performance.

**ⓘ For More Information**

Visit the IGERT web site, http://www.nsf.gov/igert.

**4. NSF-NATO Postdoctoral Fellowships in Science and Engineering (Including Special Fellowship Opportunities for Scientists from NATO Partner Countries)—**At the request of the U.S. Department of State, NSF administers a program of NATO Postdoctoral Fellowships to promote a closer collaboration among scientists and engineers of member and NATO partner countries. Approximately 25 awards are made each year to visiting scientists and engineers from NATO partner countries to enable them to conduct research at institutions in the United States and to U.S. scientists or engineers to enable them to conduct research in other NATO member or NATO partner countries.

**Eligibility Requirements for NSF-NATO Fellowships**

U.S. citizens, nationals, and permanent residents who have received their doctoral degree in science and engineering within the past 5 years, or who will have done so by the start of the fellowship, are eligible to apply for the program. Applications from citizens of NATO partner countries must be submitted through a principal investigator at a U.S. institution.

**ⓘ For More Information**

Send an inquiry via e-mail to nsf-nato@nsf.gov or visit the program's web site, http://www.ehr.nsf.gov/dge/programs/nato/.

**5. Travel Grants for NATO Advanced Study Institutes (ASI)—**NSF awards travel grants of $1,000 each to enable U.S. science and engineering graduate students and junior postdocs to attend select NATO Advanced Study Institutes held in the NATO member or partner countries of Europe. These 2- to 3-week instructional courses, conducted by noted scientists and engineers, are scheduled throughout the year, although the majority of them are held during the summer.

**Eligibility Requirements for NATO Advanced Study Institutes**

The director of a NATO Advanced Study Institute may nominate a U.S. citizen, national, or permanent resident who is a graduate student or who has received a Ph.D. within the past 3 years and has been accepted at a NATO institute.

### For More Information

Send an inquiry via e-mail to nato-asi@nsf.gov or visit the program's web site, http://www.ehr.nsf.gov/dge/programs/asi/.

## DIVISION OF HUMAN RESOURCE DEVELOPMENT

The Division of Human Resource Development (HRD) within the Directorate for Education and Human Resources serves as a focal point for NSF's agency-wide commitment to enhancing the quality and excellence of science, mathematics, engineering, and technology (SMET) education and research through broadening participation by underrepresented groups and institutions. The Division's programs aim to increase the participation and advancement of underrepresented minorities and minority-serving institutions, women and girls, and persons with disabilities at every level of the science and engineering enterprise. These programs contribute to development of a diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens. Programs within HRD have a strong focus on partnerships and collaborations in order to maximize the preparation of a well-trained scientific and instructional workforce for the new millennium.

- **Minorities and Minority-Serving Institutions**
- **Women and Girls**
- **Persons with Disabilities**
- **Crosscutting**

### For More Information

Write to the Division of Human Resource Development, National Science Foundation, 4201 Wilson Boulevard, Room 815, Arlington, VA 22230; or contact the division by telephone, 703-292-8640; or visit the HRD home page, http://www.ehr.nsf.gov/EHR/HRD/default.asp.

### MINORITIES AND MINORITY-SERVING INSTITUTIONS

Minority groups underrepresented in science, mathematics, engineering, and technology (SMET) disciplines include American Indians/Alaska Natives (Native Americans), African Americans, Hispanic Americans, and Native Pacific Islanders. The Division of Human Resource Development's (HRD) supported efforts for minority and other students are focused on two major objectives: (1) developing students and (2) strengthening the research capabilities of minority institutions. HRD programs represent a coherent effort to stimulate organizational and institutional change; markedly improve the quality of educational opportunities available to minority and other students; and increase the quality and quantity of these students who are pursuing degrees in science, mathematics, engineering, and technology disciplines. Programs supporting minorities and minority-serving institutions are as follows:

1. **Historically Black Colleges and Universities–Undergraduate Program**
2. **Louis Stokes Alliances for Minority Participation**
3. **Alliances for Graduate Education and the Professoriate**
4. **Centers of Research Excellence in Science and Technology**
5. **Tribal Colleges and Universities Program**

**1. Historically Black Colleges and Universities—Undergraduate Program—** Seeks to enhance the quality of undergraduate science, mathematics, engineering, and technology (SMET) education at Historically Black Colleges and Universities as a means to broaden participation in the Nation's SMET workforce. The program provides support for the implementation of comprehensive institutional strategies to strengthen SMET teaching and learning in ways that will improve the access and retention of underrepresented groups in SMET. Typical project implementation strategies include SMET course and curricular reform and enhancement; faculty professional development; supervised research and other active learning experiences for SMET undergraduates; student support; scientific instrumentation to improve SMET instruction; and other activities that meet institutional needs.

**Eligibility Requirements**

Historically Black Colleges and Universities that currently offer associate, baccalaureate, or master's degrees in SMET fields but do not offer doctoral degrees in SMET disciplines are eligible.

**For More Information**

Visit the web site, http://www.ehr.nsf.gov/EHR/HRD/hbcu.asp.

**2. Louis Stokes Alliances for Minority Participation (LSAMP)—**Is designed to develop the comprehensive strategies necessary to strengthen the preparation of minority students and increase the number of minority students who successfully complete baccalaureates in science, mathematics, engineering, and technology (SMET) fields. This objective facilitates the long-term goal of increasing the production of Ph.D.'s in SMET fields, with an emphasis on entry into faculty positions.

The LSAMP Program requires each awardee to establish meaningful partnerships among academic institutions, and encourages the inclusion of Government agencies and laboratories, industry, and professional organizations. It is expected that successful partnerships will enable the development of approaches tailored to the institutional setting for achievement of program goals in SMET undergraduate education. Activities supported include student enrichment, such as collaborative learning, skill development, and mentoring; academic enrichment, such as curricular and instructional improvement; and direct student support, such as summer activities.

**Eligibility Requirements**

Academic institutions with a track record of educating minority and other students in SMET disciplines are eligible to apply to the LSAMP Program. Nonprofit organizations serve as members of the alliance or partnership.

**For More Information**

Visit the web site, http://www.ehr.nsf.gov/EHR/HRD/amp.asp.

**3. Alliances for Graduate Education and the Professoriate (AGEP)—**Seeks to significantly increase the number of American Indian/Alaska Native (Native American), African American, Hispanic American, and Native Pacific Islander students receiving doctoral degrees in the physical and life sciences, mathematics, and engineering (SME). The lack of role models and mentors in the professoriate constitutes a significant barrier to producing minority SME doctoral graduates, and NSF is particularly interested in increasing the

number of minorities who will enter the professoriate in these disciplines.

Specific objectives of the AGEP Program are (1) to develop and implement innovative models for recruiting, mentoring, and retaining minority students in SME doctoral programs; and (2) to develop effective strategies for identifying and supporting underrepresented minorities who want to pursue academic careers.

The AGEP Program also supports a research effort to identify major factors that promote the successful transition of minority students from (1) undergraduate through graduate study; (2) course-taking in the early years of the graduate experience to independent research required for completion of a dissertation; and (3) the academic environment to the SME workplace. To accomplish this objective, the research component will be informed by a portfolio of Federal and private efforts in this arena in order to identify factors underlying exemplary as well as unsuccessful efforts.

**Eligibility Requirements for AGEP**

Alliances consisting of SME doctoral degree-granting institutions are eligible to apply to the program. One institution must be designated as the lead institution for the project. Institutions in the United States and its territories that have documented success in graduating minority students at the Ph.D. level are strongly encouraged to participate. Alliances are encouraged to establish partnerships with minority-serving undergraduate institutions to enhance recruitment efforts, where appropriate.

**ⓘ For More Information**

Visit the web site, http://www.ehr.nsf.gov/EHR/HRD/agep.asp

**4. Centers of Research Excellence in Science and Technology (CREST)—**NSF recognizes that academic institutions with significant minority student enrollments play a vital role in conducting the research that contributes to our knowledge base in all disciplines and in educating minority students who go on to careers in the fields of science, mathematics, engineering, and technology (SMET).

The CREST Program makes substantial resources available to upgrade the capabilities of the most research-productive minority institutions. It develops outstanding research centers through the integration of education and research. In addition, it serves to promote the production of new knowledge; increase the research productivity of individual faculty; and expand a diverse student presence in SMET disciplines. CREST centers enhance the effectiveness of related science and engineering activities within the project's area of research focus.

**Eligibility Requirements for CREST**

Institutions eligible to participate in CREST Research Infrastructure Improvement (RII) awards must have the following:

- Enrollments of 50 percent or more members of underrepresented minority groups among those holding advanced degrees in science and engineering (e.g., Alaska Natives [Eskimo or Aleut], American Indian, African American, Native Pacific Islanders [Polynesian or Micronesian], Hispanic or Latino);

- Graduate programs in NSF-supported fields of science or engineering;

- Demonstrated strengths in NSF-supported fields, as evidenced by an existing or developing capacity to offer doctoral degrees in one or more science and engineering disciplines;

- A willingness and capacity to serve as a resource center in one or more research thrust areas;

- A demonstrated commitment and track record in enrolling and graduating minority scientists and engineers; and

- Strong collaborations in the proposed field of research.

**ⓘ For More Information**

Visit the CREST web site, http://www.ehr.nsf.gov/EHR/HRD/crest.asp

**5. Tribal Colleges and Universities Program (TCUP)—**The TCUP Program provides awards to enhance the quality of science, mathematics, engineering, and technology (SMET) instructional and outreach programs, with an emphasis on the leveraged use of information technologies at Tribal Colleges and Universities, Alaska Native-serving institutions, and Native Hawaiian-serving institutions. Support is available for the implementation of comprehensive institutional approaches to strengthen SMET teaching and learning in ways that improve access to, retention within, and graduation from SMET programs, particularly those that have a strong technological foundation. Through this program, assistance is provided to eligible institutions in their efforts to bridge the digital divide and prepare students for careers in information technology, science, mathematics, and engineering fields. Proposed activities should be the result of a careful analysis of institutional needs, address institutional and NSF goals, and have the potential to result in significant, sustainable improvements in SMET program offerings. Typical project implementation strategies include curriculum enhancement, faculty professional development, undergraduate research and community service, academic enrichment, infusion of technology to enhance SMET instruction, collaborations, and other activities that meet institutional and community needs.

**Eligibility Requirements for TCUP**

Organizations eligible include Tribal Colleges and Universities, Alaska Native-serving institutions, and Native Hawaiian-serving institutions.

**ⓘ For More Information**

Visit the web site, http://www.ehr.nsf.gov/EHR/HRD/tcup.asp.

## WOMEN AND GIRLS

**Program for Gender Equity in Science, Mathematics, Engineering, and Technology**

All of the divisions within the EHR Directorate encourage projects that will increase the participation of women and girls in science and engineering. Because women are underrepresented in many disciplines, the Human Resource Development (HRD) Division supports research on focused interventions that are specifically directed toward increasing the number of women as full participants in the mainstream of the Nation's scientific and technological enterprise. The program supports the following activities:

- **Research—**This area seeks to enhance the multidisciplinary understanding of gender differences in human learning—behavioral, cognitive, affective, and social aspects—through sociopsychological, ethnographic, statistical, anthropological, economic, and organizational studies. The efforts in this area provide a research foundation for educational approaches, curriculum materials, and technological tools that are already developed or can be

developed in the future, bridging research and educational practice in settings such as classrooms, informal learning sites, and technological learning environments. The research aims to produce cumulative, reproducible, sustainable, and scalable results, supporting sustained improvement in educational practice.

- **Demonstration or "Model" Projects—**This area employs evaluation methods to determine the effectiveness of new learning tools, pedagogies, professional development programs, or student programs and services in order to produce outcomes. Demonstration projects apply research findings about girls' learning preferences in the design of new curriculum materials, services, pedagogy, or instructor development programs, which can be institutionalized and replicated if they are proven successful. In particular, teacher and faculty development demonstrations test new ways to integrate the understanding and awareness of gender-inclusive practices into preservice and in-service professional development programs and into professional standards and policies. It is anticipated that direct participants in demonstration projects will benefit from the learning experience and assimilate new behaviors.

- **Information Dissemination Activities—**This area supports projects that focus on the dissemination of research results or the dissemination of strategies for reducing the barriers for women and girls in these fields. Activities supported include media (e.g., videotapes and brochures), conferences, teleconferences, symposia, and workshops that bring together experts to discuss issues, projects, policies, and research related to the participation and achievement of women and girls in science, engineering, and mathematics. Dissemination projects take material or model approaches or information to a significant national audience.

**For More Information**

Visit the PGE web site, http://www.ehr.nsf.gov/EHR/HRD/pge.asp.

## PERSONS WITH DISABILITIES

### Program for Persons with Disabilities (PPD)

PPD is dedicated to increasing the number of people with disabilities employed in the Nation's science, engineering, and technology workforce. To accomplish this, PPD supports projects designed to

- bring about needed changes in academic and professional climates;
- increase the awareness and recognition of the needs and capabilities of students with disabilities;
- promote the accessibility and appropriateness of instructional materials, media, and educational technologies; and
- increase the availability of student enrichment resources, including mentoring activities.

In short, efforts are dedicated to changing the factors wherein neglect, paucity, and indirection historically restricted the study of science and mathematics by students with disabilities and impeded the advancement of these individuals as they prepared themselves for careers in SMET fields. In support of the goals, and in recognition of findings from past activities, PPD is initiating support for regional alliances.

**For More Information**

Visit the PPD web site, http://www.ehr.nsf.gov/EHR/HRD/ppd.asp.

## CROSSCUTTING

### Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring (PAESMEM)

The White House established the PAESMEM Program to recognize the importance of role models and mentors in the academic, professional, and personal development of students from groups that are underrepresented in these fields. PAESMEM identifies outstanding mentors and mentoring programs that enhance the experiences of underrepresented students in the sciences, mathematics, and engineering. At the individual and the institutional levels, recipients of the PAESMEM award have been exemplary in their demonstration of the idea that the Nation must develop its human resources in these disciplines to the fullest extent possible through support of increased access by diverse populations.

Nominees, both individual and institutional, must have served as mentors or facilitated mentoring services for at least 5 years. Awards are made to (1) individuals who have demonstrated outstanding and sustained mentoring and effective guidance to a significant number of students at the K–12, undergraduate, or graduate level of education; and (2) institutions that have, through their programming, enabled a substantial number of students from groups traditionally underrepresented in science, mathematics, and engineering to pursue and complete relevant degree programs successfully (at the postsecondary level, these efforts must show that students have completed either a baccalaureate, master's, or doctoral degree).

**For More Information**

Visit the PAESMEM web site, http://www.ehr.nsf.gov/EHR/HRD/paesmem.asp.

# DIVISION OF RESEARCH, EVALUATION, AND COMMUNICATION

The Division of Research, Evaluation, and Communication (REC) provides a research-based foundation for teaching and learning in science, mathematics, engineering, and technology (SMET), using the results of research in technology utilization, content, pedagogy, assessment, and policy-oriented studies and indicators. The REC Division supports projects that investigate the learning process and integrate research with educational practices, including those that provide the groundwork for the effective use of technology. The division provides support for NSF's participation in the Interagency Education Research Initiative (IERI), various international comparative studies such as the Third International Mathematics and Science Study (TIMSS), and the EHR Directorate's participation in the agency-wide Faculty Early Career Development Program (see the CAREER home page, http://www.nsf.gov/home/crssprgm/career/start.htm). Through periodic program evaluations, REC activities also analyze the development, implementation, and impact of science and mathematics programming across the EHR Directorate.

The REC Division supports the following programs and activities:

1. **Research on Learning and Education**
2. **Evaluation**

### For More Information

Write to the Division of Research, Evaluation, and Communication, National Science Foundation, 4201 Wilson Boulevard, Room 855, Arlington, VA 22230; or contact the division by telephone, 703-292-8650, or by e-mail, REC@nsf.gov; or visit the REC home page, http://www.ehr.nsf.gov/EHR/REC.

**1. Education Research—**The REC Division sponsors a comprehensive education research program, Research on Learning and Education (ROLE), to support the knowledge base that undergirds improvement in math and science instruction; provide more efficient use of educational technologies; and develop a more effective math and science instructional workforce. The ROLE Program supports research in several domains, including basic research in neural and cognitive sciences; teaching, learning, and institutional change processes; exploratory development of new instructional approaches; materials and implementation models whose impact can be systematically evaluated; studies of systemic factors in implementing educational innovations; policy studies; and collaborative research and development proposals on new and evolving information technologies.

**2. Evaluation—**Provides support for the assessment of NSF education and training programs and coordinates the evaluation of similar initiatives in other Federal agencies for the purpose of program improvement, accountability, and a generation of new knowledge for the education community at large. Evaluations are usually supported through competitively awarded contracts to outside organizations. Occasionally, the program solicits grant proposals for evaluative studies of NSF or other national science and mathematics programs of interest. The program may also accept proposals for the development of innovative techniques, approaches, and methodologies for the general improvement of education evaluation.

## DIVISION OF UNDERGRADUATE EDUCATION

The Division of Undergraduate Education (DUE) serves as the focal point for NSF's efforts in undergraduate education. Whether preparing students to participate as citizens in a technological society; enter the workforce with 2- or 4-year degrees; continue their formal education in graduate school; or further their education in response to new career goals or workplace expectations, undergraduate education provides the critical link between the Nation's secondary schools and a society increasingly dependent on science and technology.

DUE's programs and leadership efforts aim to strengthen the vitality of undergraduate science, mathematics, engineering, and technology (SMET) education for all students, including SMET majors, prospective teachers of grades preK through 12, students preparing for the technical workplace, and students in their role as citizens in society at large.

Projects submitted to programs in DUE are encouraged to incorporate, as appropriate, features that address one or more of four themes that have been targeted for special emphasis. These themes are (1) teacher preparation, (2) professional development for faculty, (3) increasing diversity within SMET fields, and (4) integrating technology in education. Although the activities described below are expected to constitute the majority of projects supported through DUE, proposals that address other

mechanisms for improving undergraduate SMET education will be considered.

DUE supports the following programs and activities:

1. **Advanced Technological Education**
2. **Assessment of Student Achievement in Undergraduate Education**
3. **Course, Curriculum, and Laboratory Improvement**
4. **Federal Cyber Service: Scholarship for Service**
5. **NSF Computer Science, Engineering, and Mathematics Scholarships**
6. **NSF Director's Award for Distinguished Teaching Scholars**
7. **National Science, Mathematics, Engineering, and Technology Education Digital Library**
8. **Science, Technology, Engineering, and Mathematics Teacher Preparation**

## ⓘ For More Information

Write to the Division of Undergraduate Education, National Science Foundation, 4201 Wilson Boulevard, Room 835, Arlington, VA 22230; or contact the division by telephone, 703-292-8670, or by e-mail, undergrad@nsf.gov; or visit the DUE home page, http://www.ehr.nsf.gov/EHR/DUE/.

**1. Advanced Technological Education (ATE)—**Is managed jointly by DUE and the Division of Elementary, Secondary, and Informal Education. The program promotes improvement in the education of technicians in science and engineering related fields at the undergraduate and secondary school levels. It particularly targets two-year colleges and encourages collaboration among 2-year colleges, 4-year colleges, universities, secondary schools, business, industry, and government. Proposals are solicited in the following three tracks:

- **Projects—**Activities may include the development of educational materials, courses, curricula, and laboratories; the preparation and professional development of college faculty and secondary school teachers; internships and field experiences for students and educators; or the dissemination of exemplary educational materials, curricula, and pedagogical practices designed by previously funded ATE centers and projects.

- **Centers—**ATE centers are comprehensive national or regional resources that provide models and leadership for other projects and act as clearinghouses for educational materials and methods. National Centers of Excellence engage in the full range of activities described above for projects. Regional Centers for manufacturing or information technology education pursue comprehensive approaches that focus on reforming academic programs, departments, and systems to produce a highly qualified workforce to meet industry's needs within a particular geographic region.

- **Articulation Partnerships—**These projects focus on enhancing either of two important educational pathways for students between 2-year colleges and 4-year colleges and universities. One type of Articulation Partnership focuses on strengthening the science, mathematics, and technology preparation of prospective K–12 teachers who are enrolled in preprofessional programs at 2-year colleges. The other type of partnership targets 2-year college programs for students to continue their education in 4-year science, mathematics, engineering, and technology programs, especially programs that have a strong technological basis.

Proposals in all three tracks must show evidence of a coherent vision of

technological education—a vision that recognizes the needs of the modern workplace, the needs of students as lifelong learners, and the need for articulation of educational programs at different levels. Whenever feasible, projects are expected to utilize and innovatively build from successful educational materials, courses, curricula, and methods that have been developed through other ATE grants, as well as other exemplary resources that can be adapted to technological education.

**For More Information**

Visit the ATE Program web site, http://www.ehr.nsf.gov/EHR/DUE/programs/ate/.

**2. Assessment of Student Achievement (ASA) in Undergraduate Education—** Supports the development and dissemination of assessment practices, materials (tools), and measures to guide efforts that improve the effectiveness of courses, curricula, programs of study, and academic institutions in promoting student learning in science, mathematics, engineering, and technology (SMET). ASA seeks to support the use of assessment practices by SMET faculty, SMET departments, and institutional administrators seeking to measure student achievement in courses, curricula, programs of study, and the cumulative undergraduate experience embodying some SMET learning.

To help ensure that project results will effectively serve the SMET community, at least one investigator (PI or co-PI) in a project must be a SMET faculty member. Projects can focus on one or more of the following broad areas:

- developing new and adapting extant assessment materials that can be used to improve SMET courses and curricula to achieve explicit learning objectives;
- developing methods for assessing student achievement resulting from a group of courses constituting a minor or major field of study;
- assessing the impact on student achievement of interdisciplinary learning experiences, student teams, cocurricular activities (e.g., service learning), increased laboratory and field experiences, and other forms of learning enrichment; and
- developing indicators of student learning within certain domains, and measures of institutional program quality.

**For More Information**

Visit the ASA Program web site, http://www.ehr.nsf.gov/EHR/DUE/programs/asa/.

**3. Course, Curriculum, and Laboratory Improvement (CCLI)—**Supports projects that are expected to improve undergraduate science, mathematics, engineering, and technology education (SMETE) by increasing the availability and use of high-quality educational materials and the employment of effective pedagogical strategies. Proposals that address all levels of undergraduate education are encouraged; proposals to improve introductory-level courses, curricula, and laboratories are especially welcome.

The CCLI Program invites proposals to improve undergraduate SMETE in a broad spectrum of institutions, including 2-year colleges, 4-year colleges, and universities. Projects may involve a single institution, a collaborative effort among several institutions, or a collaboration with business and industry partners. The CCLI Program has three major tracks:

- **Educational Materials Development Track—**Projects are expected to

produce innovative materials that incorporate effective educational practices to improve student learning of SMET. Projects to develop textbooks, software, or laboratory materials for commercial distribution are appropriate. Two types of projects will be supported: (1) those that intend to demonstrate the scientific and educational feasibility of an idea, a "proof of concept," or a prototype; and (2) those that are based on prior experience with a prototype that they intend to fully develop the product or practice. Such materials are expected to be disseminated nationally for adoption and adaptation.

- **Adaptation and Implementation Track—**Projects are expected to result in improved education in SMET at academic institutions through the adaptation and implementation of exemplary materials, laboratory experiences, and educational practices that have been developed and tested at other institutions. Proposers may request funds in any category normally supported by NSF, or funds only to purchase instrumentation.

- **National Dissemination Track—**Projects are expected to provide faculty with professional development opportunities to enable them to introduce new content into undergraduate courses and laboratories and to explore effective educational practices. Projects should be designed to offer workshops, short courses, or similar activities on a national scale in single or multiple disciplines.

**For More Information**

Visit the CCLI Program web site, http://www.ehr.nsf.gov/EHR/DUE/programs/ccli/.

**4. Federal Cyber Service: Scholarship for Service (SFS)—**Seeks to increase the number of qualified students entering the fields of information assurance and computer security and to increase the capacity of higher education enterprise in the United States to continue to produce professionals in these fields. The program consists of the following scholarship and capacity-building tracks:

- **Scholarship—**Provides funding to colleges and universities to award scholarships in information assurance and computer security fields. Scholarship recipients will become part of the Federal Cyber Service of information technology specialists who ensure the protection of the United States Government's information infrastructure. After their 2-year scholarships, the recipients will be required to work for a Federal agency for 2 years as their Federal Cyber Service commitment.

- **Capacity Building—**Seeks to increase the national capacity for producing trained information assurance professionals by providing support to colleges and universities interested in building programs, individually or in partnership.

**For More Information**

Visit the SFS Program web site, http://www.ehr.nsf.gov/EHR/DUE/programs/sfs/.

**5. NSF Computer Science, Engineering, and Mathematics Scholarships (CSEMS)—**Provides institutions with funds to support scholarships for talented but financially disadvantaged students in computer science, computer technology, engineering, engineering technology, or mathematics degree programs. Through support from this program, grantee institutions establish scholarships that promote full-time enrollment and completion of degrees in higher education in the above

fields. NSF established the program in accordance with the American Competitiveness and Workforce Improvement Act of 1998 (Public Law 105-277). The Act reflects the Nation's need to increase substantially the number of graduates from associate, baccalaureate, and graduate degree programs in these fields. The goals of this program are to

- improve education for students in the stated disciplines;
- increase retention of students to degree completion;
- improve professional development, employment, and further higher education placement of participating students; and
- strengthen partnerships between institutions of higher education and related employment sectors.

The eligibility criteria for a CSEMS scholarship recipient include the following:

- must show status as a U.S. citizen, national, refugee alien, or permanent resident alien at the time of application;
- full-time enrollment in a computer science, computer technology, engineering, engineering technology, or mathematics degree program at the associate, baccalaureate, or graduate level;
- demonstrated academic potential or ability; and
- demonstrated financial need, defined for undergraduates as financial eligibility under U.S. Department of Education rules for Federal financial aid, and defined for graduate students as eligibility for Graduate Assistance in Areas of National Need.

CSEMS institutional proposers must be institutions of higher education that grant degrees in computer science, computer technology, engineering, engineering technology, or mathematics.

**For More Information**

Visit the CSEMS Program web site, http://www.ehr.nsf.gov/EHR/DUE/programs/csems/csems.htm.

**6. NSF Director's Award for Distinguished Teaching Scholars (DTS)—**DTS recognizes individuals with demonstrated excellence and promise of future success in both scientific research and the education of undergraduates in science, mathematics, engineering, and technology (SMET). The program promotes the continued and expanded efforts of individuals with a history of impact on both (a) the research in a SMET discipline or on SMET educational research; and (b) the SMET education of undergraduates, including those who are not SMET majors. The Director's Award is the highest honor bestowed by the NSF for excellence in both teaching and research in SMET fields, or in educational research related to these disciplines.

**For More Information**

Visit the DTS Program web site, http://www.ehr.nsf.gov/EHR/DUE/programs/dts/.

**7. National Science, Mathematics, Engineering, and Technology Education Digital Library (NSDL)—**Supports the creation and development of a national digital library for science, mathematics, engineering, and technology education (SMETE). The resulting virtual facility—learning environments and resources network for SMETE—is intended to meet the needs of students and teachers at all levels: K–12, undergraduate, graduate, and lifelong learning, in both individual and collaborative settings. The NSDL Program builds on work supported under the multiagency Digital Libraries Initiative (see

http://www.dli2.nsf.gov/) and represents a synergistic collaboration of research and education efforts.

The NSDL Program is currently supporting a Core Integration effort that coordinates and manages the digital library's holdings and services. To complement and further expand this Core Integration capacity, the NSDL Program accepts proposals in the following tracks:

- **Collections—**Projects are expected to aggregate and manage a subset of the library's content within a coherent theme or specialty.

- **Services—**Projects are expected to develop services that will support users, collection providers, and the Core Integration effort, as well as enhance the impact, efficiency, and value of the library.

- **Targeted Research—**Projects are expected to explore specific topics that have immediate applicability to one of the other two tracks, or the Core Integration effort discussed above.

**ⓘ For More Information**

Visit the NSDL Program web site, http://www.ehr.nsf.gov/EHR/DUE/programs/nsdl/.

**8. Science, Technology, Engineering, and Mathematics Teacher Preparation (STEMTP)—**Supports efforts to develop exemplary science and mathematics preK–12 teacher preparation models through partnerships involving science, mathematics, engineering, technology, and education faculty at 2- and 4-year institutions of higher education and local school districts. The goals of the program are to

- increase significantly the number of preK–12 teachers who are certified and well qualified to teach mathematics and science, and

- improve the quality of preservice education, induction, and continued professional growth in mathematics and science for preK–12 teachers.

Projects must address local needs for increased numbers of teachers who are well qualified to teach mathematics and science by providing strategies for recruiting and retaining teachers in the workforce. The STEMTP Program offers the following two areas of focus:

a. Baccalaureate and 5-Year Programs—Projects are expected to include strategies for ensuring that preservice students acquire SMET content and pedagogical knowledge and skills for successful teaching.

b. Alternative Pathways to Teaching—Projects are expected to design and implement alternative credentialing programs for SMET professionals and recent SMET graduates to facilitate their entry into the teaching profession.

**ⓘ For More Information**

Visit the STEMTP Program web site, http://www.ehr.nsf.gov/EHR/DUE/programs/stemtp/.

## EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH

The Experimental Program to Stimulate Competitive Research (EPSCoR) increases the research and development (R&D) competitiveness of 21 States and the

Commonwealth of Puerto Rico. The States are Alabama, Alaska, Arkansas, Hawaii, Idaho, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, New Mexico, Nevada, North Dakota, Oklahoma, South Carolina, South Dakota, Vermont, West Virginia, and Wyoming.

EPSCoR offers two types of funding, and an accompanying outreach program supports improvements in R&D competitiveness:

- **EPSCoR Research Infrastructure Improvement Awards—**Provide 36-month awards of up to $9 million to support infrastructure improvements in science and technology areas selected by the State's EPSCoR governing committee as being important to the State's future R&D competitiveness.

- **EPSCoR Cofunding—**Provides partial support for proposals that have been reviewed at or near the cutoff for funding by regular programs and special initiative competitions throughout NSF.

- **Outreach—**Involves senior NSF personnel working with EPSCoR researchers and their institutions to acquaint them with NSF priorities, programs, policies, and procedures.

## ⓘ For More Information

Write to EPSCoR, Directorate for Education and Human Resources, National Science Foundation, 4201 Wilson Boulevard, Room 875, Arlington, VA 22230; or contact the program by telephone, 703-292-8683, or by e-mail, jhoehn@nsf.gov; or visit the EPSCoR home page, http://www.ehr.nsf.gov/epscor/.

# ENGINEERING

The Directorate for Engineering (ENG) supports engineering research and education in a competitive environment that places strong emphasis on innovation, creativity, and excellence. This support benefits the Nation by creating the human resources and knowledge that spur technological innovation and economic growth in an increasingly swift, complex, and interconnected world. A significant portion of ENG's funds is invested in investigator-initiated research. Although the research supported by ENG is fundamental in nature, much of it is focused on societal needs. Over the long term, ENG investments contribute to innovation that enables the creation of valuable new products and services and new and more productive enterprises that enhance the Nation's future economic strength, security, and quality of life.

ENG's investment and partnerships with academe, Federal agencies, and private industry as well as collaboration with other National Science Foundation (NSF) directorates in the emerging technologies of microsystems and nanotechnology, information technology, and biotechnology enable significant advances in health care, manufacturing, education, and the service industry. For example, awards made by the Grant Opportunities for Academic Liaison with Industry (GOALI) Program, which receives strong ENG support, bring university and industry collaborators together at the conceptual phase of a research and education endeavor. Strengthening these intellectual connections increases the value of engineering education and fundamental research to the private sector and opens up exciting new areas of research.

Overall, the National Science Foundation (NSF) provides about 36 percent of the total Federal support for fundamental engineering research at universities and colleges in the United States.

The Directorate for Engineering supports programs and activities through the following:

- **Crosscutting Programs and Activities**
- **Division of Bioengineering and Environmental Systems (BES)**
- **Division of Chemical and Transport Systems (CTS)**
- **Division of Civil and Mechanical Systems (CMS)**
- **Division of Design, Manufacture, and Industrial Innovation (DMII)**
- **Division of Electrical and Communications Systems (ECS)**
- **Division of Engineering Education and Centers (EEC)**

## ⓘ For More Information

Visit the ENG Directorate home page, http://www.eng.nsf.gov/.

# CROSSCUTTING PROGRAMS AND ACTIVITIES

### NSF-Wide Activities

In addition to the programs and activities mentioned in this section, the Directorate for Engineering (ENG) also takes an active role in the following NSF-wide programs and activities: the Faculty Early Career Development (CAREER) Program, Research Experiences for Undergraduates (REU), Integrative Graduate Education and Research Training (IGERT), Graduate Fellowships, Grant Opportunities for Academic Liaison with Industry (GOALI), Major Research Instrumentation (MRI), undergraduate activities, minority and women's programs, and programs for persons with disabilities.

### ⓘ For More Information

Visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm/.

### Engineering-Wide Activities

The ENG Directorate also has programs that are available across all of its divisions. These include the Combined Research-Curriculum Development Program and supplemental support for underrepresented research assistants on engineering grants. For information about these programs, see the Division of Engineering Education and Centers (EEC) section of this Guide; or visit the EEC home page, http://www.eng.nsf.gov/eec/.

# DIVISION OF BIOENGINEERING AND ENVIRONMENTAL SYSTEMS

The Division of Bioengineering and Environmental Systems (BES) supports research that

- expands the knowledge base of bioengineering at scales ranging from proteins and cells to organ systems, including mathematical models, devices, and instrumentation systems. BES is particularly interested in postgenomic engineering, metabolic engineering, and tissue engineering. BES continues its strong interest in upstream and downstream processing of proteins and other biochemicals (see the Biochemical Engineering and Biotechnology Program, below, for more information).

- applies engineering principles to the models and tools used in understanding living systems, and to products for human health care. BES supports the development of prototypes for new and improved devices and software for persons with disabilities. Emphasis is placed on basic engineering research that will contribute to better and more efficient health care delivery and that will aid people with disabilities. Current areas of interest include biomedical photonics and sensing (see the Biomedical Engineering Program, below, for more information).

- improves our ability to apply engineering principles to avoid and correct problems that impair the usefulness of land, air, and water. Current interest areas include environ-mental remediation, especially with respect to understanding the fate and transport of

surface and groundwater pollutants; novel processes for waste treatment; industrial ecology; technologies for avoiding pollution; and technology to limit fouling of the ocean (see the Environmental Engineering Program, below, for more information).

The BES Division supports the following programs and activities:

1. **Biochemical Engineering and Biotechnology**
2. **Biomedical Engineering and Research to Aid Persons with Disabilities**
3. **Environmental Engineering**

### ⓘ For More Information

Write to the Division of Bioengineering and Environmental Systems, National Science Foundation, 4201 Wilson Boulevard, Room 565, Arlington, VA 22230; or contact the division by telephone, 703-292-8320 or by fax, 703-292-9098; or visit the BES home page, http://www.eng.nsf.gov/bes/.

**1. Biochemical Engineering and Biotechnology—**Supports research that links the expertise of engineering with that of the life sciences to provide a fundamental basis for economical manufacturing of substances of biological origin. Engineers and small groups of engineers and scientists are encouraged to apply for support. Synergy among the various disciplines in these types of projects is a very important evaluation criterion.

Current areas of interest within the program include the following:

- **Post-Genomic Engineering––** Quantitative methods for predicting the phenotypic behavior of proteins, pathways, and cells from genomic data.
- **Metabolic Engineering––**Methods for understanding and beneficially altering the chemical pathways of living systems.
- **Tissue Engineering––**Development of polymeric scaffolding, imbedding of cells, cell-to-cell communications, tissue biomechanics, and so forth.
- **Bioprocessing––**Novel bioreactors and processing systems and controls; major changes in downstream isolation and purification.

**2. Biomedical Engineering and Research to Aid Persons with Disabilities—**Supports fundamental engineering research that has the potential to contribute to improved health care and to the reduction of health care costs. Other areas of interest include models and tools for understanding biological systems; fundamental improvements in deriving information from cells, tissues, organs, and organ systems; extraction of useful information from complex biomedical signals; new approaches to the design of structures and materials for eventual medical use; and new methods of controlling living systems. The program is also directed toward the characterization, restoration, and substitution of normal functions in humans. Emphasis is on the advancement of fundamental engineering knowledge rather than on product development. The research could lead to the development of new technologies or to the novel application of existing technologies rather than to product development. Also supported are undergraduate engineering design projects, especially those that provide prototype "custom-designed" devices or software for persons with mental or physical disabilities. New areas of research interest include biomedical photonics and sensors.

**3. Environmental Engineering—** Supports sustainable, developmental research, the goal of which is to reduce the adverse effects on land, fresh and salt water, and air that are brought on by the solid, liquid, and gaseous discharges that result from human activity, thus impairing the value of those resources. The program also supports innovative research in the areas of biological, chemical, and physical processes that are used alone or as components of engineered systems to restore the usefulness of the polluted land, water, and air resources. Emphasis is on engineering principles that underlie pollution avoidance and pollution treatment and repair. Improved sensors, innovative production processes, waste reduction and recycling, and industrial ecology are important to this program. Research may be directed toward improving the cost-effectiveness of pollution avoidance as well as developing new principles for pollution avoidance technologies. The program places particular emphasis on engineering principles that underlie pollution avoidance.

# DIVISION OF CHEMICAL AND TRANSPORT SYSTEMS

Technologies and processes for transforming materials and energy are critical to improving the living standards and prolonging the lives of people. The Division of Chemical and Transport Systems (CTS) supports research that contributes to the knowledge base important for a large number of industrial processes and for some natural processes that involve the transformation of matter and energy. Important sectors of the global economy based on these technologies and processes include chemicals, pharmaceuticals, petroleum, synthetic and natural materials, aerospace, energy generation, and utilization industries.

CTS research support is directed to fundamental engineering principles involving mathematical models of macro and molecular systems and experimental techniques. Emphasis is on projects that have the potential for innovation and broad application in areas related to environmental preservation, materials development, and chemical and thermal processing. Increased emphasis is being placed on processing of nanostructured materials, environmentally benign chemical and materials processing, sustainable and more efficient energy sources, and effective coupling of research and education.

The CTS Division supports the following thematic areas and programs:

1. **Chemical Reaction Processes**
2. **Interfacial, Transport, and Separation Processes**
3. **Fluid and Particle Processes**
4. **Thermal Systems**

## ⓘ For More Information

Write to the Division of Chemical and Transport Systems, National Science Foundation, 4201 Wilson Boulevard, Room 525, Arlington, VA 22230; or contact the division by telephone, 703-292-8371, or by fax, 703-292-9054; or visit the CTS home page, http://www.eng.nsf.gov/cts/.

**1. Chemical Reaction Processes—**This theme consists of two subelements: (a) Process and Reaction Processes (PRP) and (b) Kinetics, Catalysis, and Molecular Processes (KCMP). Activities supported through these subelements include research on rates and mechanisms of important classes of catalyzed and uncatalyzed chemical reactions as they

relate to the design, production, and application of catalysts, chemical processes, and specialized materials; fundamental theories and novel modeling and simulation approaches to reactive molecular processes; molecular modeling to relate atomistic-level phenomena to plant-scale design; single-molecule mechanisms and characterization; molecular motors; combinatorial catalysis and combinatorial chemistry; automated parallel synthesis and high-throughput screening; catalytic and materials process informatics; catalysis in medicine and life processes; reactions in nanoenvironments; large-scale kinetics databases and intelligent data management; distributed and collaborative reactive process characterization; bio-inspired reactive process design; nanofabricated reactive processes; nanophase control in reactive processes; electrochemical and photochemical processes; environmentally sustainable and abundant feedstocks; wasteless pathways and pollution prevention; low-temperature chemical processes; single-step processing; combined reaction and separation; design and optimization of complex chemical processes, including scheduling and supply chain modeling; dynamic modeling and control of processes; sensors for chemical or life systems for process and quality control; processing of materials for electronics, optoelectronics, quantum, and single-electron computing; magnetic and ferroelectric materials for digital data storage; fine and specialty chemicals, including pharmaceuticals, agrochemicals, intermediates for consumer products, transportation, foods, flavors, and fragrances; reactive processing of polymers, ceramics, and thin films; global integration of chemical processes within the service economy; and interactions between chemical reactions and transport processes in reactive systems and the use of this information in the design of complex chemical reactors.

**2. Interfacial, Transport, and Separation Processes—**Activities supported through the subelements in this theme support research in areas related to interfacial phenomena and mass transport, separation science, and phase equilibrium thermodynamics. The two subelements are (a) Interfacial, Transport, and Thermodynamics (ITT) and (b) Separation and Purification Processes (SPP).

- Interfacial, Transport, and Thermodynamics (ITT)—Major focus areas include advanced materials processing and environmentally benign processing. The program provides support for fundamental approaches and theories that deal with the thermo-dynamics of complex fluids and transport phenomena at interfaces of synthetic and biological systems, and the processing of nanoscale materials and thin films. The ITT Program also supports research aimed at minimizing hazardous products in chemical and materials manufacturing, with a focus on environmentally friendly coatings, alternate reactions, and processing media.

- Separation and Purification Processes (SPP)—Major focus areas include development of functional materials as effective mass-separation agents; high-performance computing and modeling applied to separation processes; and novel strategies that combine several phenomena to accomplish effective separations. The SPP Program supports basic research involving novel membranes and adsorbents; modeling and computations applied over a range of scales, from a molecular level to macroscale analysis of separation processes; and separations utilizing combined effects of controlled hydrodynamics, adsorption phenomena, electrical or magnetic fields, and chemical reactions.

**3. Fluid and Particle Processes—**This theme consists of two subelements: (a) Particulate and Multiphase Processes (PMP) and (b) Fluid Dynamics and Hydraulics (FDH). Activities supported through these subelements include fundamental research on mechanisms and phenomena that govern single- and multiphase fluid flow; particle formation and transport; various multiphase processes; synthesis and processing of nanostructured materials; and fluid and solid system interactions. The common research theme across this broad range of topical areas is the expectation that new conceptual understanding, innovative approaches to a recognized problem, and the identification of a new line of investigation will be established as a result of the proposed research. Research is sought that will help to improve the basic understanding of the governing mechanics responsible for the motion of fluids and particulates. It is expected that these investigations will supply the engineering science knowledge base to support innovative approaches in areas such as manufacturing, materials, nano- and biotechnology, process industries, transportation, and the environment.

**4. Thermal Systems—**This theme consists of two subelements: (a) Thermal Transport and Thermal Processing (TTP) and (b) Combustion and Plasma Systems (CPS).

- Thermal Transport and Thermal Processing (TTP)—Supports projects that seek a basic understanding of heat transfer, particularly at the micro- and nanoscale levels, and that apply heat and mass transfer principles to technologically related fields. Areas in need of basic heat transfer research include photon and phonon transport in thin films; laser/radiation interactions with liquid and solid phases; macroscopic transport with microstructure formation during solidification; flow and heat transport in porous media; microjet cooling for electronic equipment; phase-change materials; rheology; and crystal growth. Examples of technologically related fields are manufacturing, laser processing and machining, welding, gas turbines, heating and ventilation systems, biotechnology, and cryogenics. The overall goal is to learn more about the fundamentals of heat transfer and the transport processes that improve the efficiency of industrial systems.

- Combustion and Plasma Systems (CPS)—Supports research on understanding the fundamental, physical, and chemical processes involved in combustion; provides principles to address major problems, such as pollutant formation in combustion, energy-conversion inefficiencies, and fire hazards; elucidates the fundamental science and engineering principles necessary for the application of plasma technology to such situations as chemical conversions, materials refining, energy recovery, and biosystems modification; and demonstrates how combustion or plasma processing can be applied to solve problems in such areas as the production of fine powders or thin films, waste destruction, sterilization, and surface modification. Major topics covered include flame chemistry, incineration, internal combustion engines, pollutant formation from combustion, models of combustion or plasma systems, diagnostics for combustion and plasmas, plasma chemistry and physics, production of particles and coatings, destruction of environmental pollutants and contaminants, and combustion synthesis. Priorities include projects related to environmental quality (both prevention and amelioration) and new manufacturing techniques, especially for materials. Support includes computational efforts in both theory and simulation, and experimental studies on real engineering systems or laboratory

models, diagnostic techniques, and real-time monitoring of processes.

# DIVISION OF CIVIL AND MECHANICAL SYSTEMS

The Division of Civil and Mechanical Systems (CMS) supports research that contributes to the knowledge base and intellectual growth in the areas of infrastructure construction and management, geotechnology, structures, dynamics and control, mechanics and materials, sensing for civil and mechanical systems, and the reduction of risks induced by earthquakes and other natural and technological hazards.

The CMS Division encourages cross-disciplinary partnerships at the intersections of traditional disciplines. These partnerships promote discoveries using technologies such as autoadaptive systems, nano-technology, and information technology to enable revolutionary advances in the Nation's civil and mechanical systems.

The CMS Division supports the following research programs and activities:

1. **Dynamic System Modeling, Sensing, and Control**
2. **Geotechnical and Geohazards Systems**
3. **Infrastructure and Information Systems**
4. **Solid Mechanics and Materials Engineering**
5. **Structural Systems and Engineering**

The CMS Division also manages the Network for Earthquake Engineering Simulation (NEES) Program, a Major Research Equipment project that began construction in fiscal year 2000 and is expected to continue through 2004. For further information, visit the program's web site, http://www.eng.nsf.gov/nees.

## ⓘ For More Information

Write to the Division of Civil and Mechanical Systems, National Science Foundation, 4201 Wilson Boulevard, Room 545, Arlington, VA 22230; or contact the division by telephone, 703-292-8360, or by fax, 703-292-9053; or visit the CMS home page, http://www.eng.nsf.gov/cms/.

**1. Dynamic System Modeling, Sensing, and Control (DSMSC)—**Supports research on the fundamental engineering concepts and mathematical theories for modeling, analysis, simulation, and control of complex, nonlinear dynamic systems, including study of new control methods; acoustics; vibrations; and kinematics relationships. DSMSC invests in research on information technology as related to smart and autoadaptive civil and mechanical systems, including the study of new technologies for sensing and acquiring information; multiple and intelligent system functionality; and modeling, synthesis, simulation, and prototyping of intelligent systems and their components. Research of this type will advance the knowledge base for integration of sensors, actuators, controllers, and power sources for autoadaptive applications.

**2. Geotechnical and Geohazards Systems (GHS)—**Seeks to advance the fundamental engineering and related knowledge for geostructures—foundations, slopes, excavations, soil and rock improvement technologies, and reinforcement systems; geohazards mitigation; constitutive modeling and verification; remediation and containment of geo-environmental contamination; transferability of laboratory results to field

scale; and nondestructive and in situ evaluation. GHS support is given for research that will increase geotechnical and geohazards knowledge necessary to mitigate the impacts of natural and technological hazards on both the constructed and the natural environment. A broad spectrum of research is supported, including the use of data from laboratory and field experiments, to verify design procedures and methodologies; simulation of phenomena; and collection of data from catastrophic events, including rapid-response reconnaissance inspections.

**3. Infrastructure and Information Systems (IIS)—**Supports research to develop new science bases necessary for developing and deploying advanced information systems and technologies required to sustain the Nation's infrastructure. IIS research affects infrastructure system design, construction, maintenance, and operation and control, and includes networking technology; Internet-based data systems; voice and data communications technologies; and geographical information systems-based multimedia global infrastructure information systems. The IIS Program is also interested in systems and network approaches to infrastructure management and life-cycle engineering; integrated systems behavior and network simulation; hazard preparedness and response; societal and economic impacts; decision theory; intelligent systems and engineering (life-cycle design); and conceptual and theoretical bases of scalable enterprise for civil systems construction and management.

**4. Solid Mechanics and Materials Engineering (SMME)—**Links the expertise of analytical, computational, and experimental solid mechanics and biomechanics with materials and surface engineering to understand, characterize, analyze, design, and control the mechanical properties and performance of materials and devices. SMME supports research on the deformation, fracture, fatigue, friction, wear, and corrosion of all types of materials, including composites, nanostructured materials, construction materials, and coatings and surface modification for service under extreme conditions. The program also supports experimental and analytical investigations and simulation modeling of material microstructures and their connections to nano-, meso-, and macroscale structural behavior.

**5. Structural Systems and Engineering (SSE)—**Emphasizes new discoveries in the design, construction, repair, rehabilitation, upgrade, and maintenance of structural materials and systems. SSE supports research that will advance the knowledge base on the application of advanced polymer materials and high-performance steel and concrete materials; durability of construction materials; soil structure interaction; safety and reliability of bridges and other structures, including applications of condition assessment to structural systems; and indoor environmental conditions. Also of interest is research that will lead to improved understanding of the impact of extreme events on the performance of the constructed environment, and on interactions between natural and constructed environments.

**6. National Science Foundation (NSF) George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES)—**A project funded under the NSF Major Research Equipment Program. NEES is authorized for a 5-year construction period through September 30, 2004, for a total of $81.8 million. The goal of NEES is to provide a national, networked collaboratory of geographically distributed, shared-use next-generation experimental research equipment sites. These sites will be equipped with teleobservation and teleoperation capabilities that will transform the environment for earthquake engineering

research and education through collaborative and integrated experimentation, computation, theory, databases, and model-based simulation. The goal is to improve the seismic design and performance of U.S. civil and mechanical infrastructure systems. When the construction is completed, the NEES Consortium will operate the NEES collaboratory through the year 2014.

The NEES collaboratory will include approximately 20 equipment sites (shake tables, centrifuges, tsunami wave basin, large-scale laboratory experimentation systems, and field experimentation and monitoring installations) networked together through the high performance Internet. In addition to providing access for telepresence at the NEES equipment sites, the network will use cutting-edge tools to link high performance computational and data storage facilities, including a curated repository for experimental and analytical earthquake engineering and related data. The network will also provide distributed physical and numerical simulation capabilities and resources for visualization of experimental and computed data.

## DIVISION OF DESIGN, MANUFACTURE, AND INDUSTRIAL INNOVATION

The Division of Design, Manufacture, and Industrial Innovation (DMII) supports fundamental academic research in design, manufacturing, and industrial engineering. DMII also manages crosscutting industrial innovation programs that encompass major components of NSF.

Technological advances, increasing global competition, and the Internet have combined to make today's manufacturing activities increasingly integrative, such that the distinction between "manufacturing" and "service" has become blurred. The mission of the Engineering Design and Manufacture research programs is to address this rapidly changing environment; the challenge it poses to the Nation's economic well-being; the expanding opportunities of the emerging service sector; and the need for an educated technical workforce for the manufacturing and service enterprises of the future.

To address this mission, DMII identifies and supports fundamental research on issues that span the areas supported within the Engineering Directorate—from design to manufacturing to service. These areas include size scales, from the "nano" environment that will drive tomorrow's manufacturing processes, to the "macro" or global enterprise scale that defines the production systems of the traditional manufacturing sector and extends into the growing service sector of the future. DMII-funded research includes an emphasis on environmentally benign manufacturing and a sustainable industrial economy, and seeks to address those fundamental issues that will deepen our understanding of the processes and systems that comprise modern design, manufacturing, and service enterprises and benefit society. The Division maintains a commitment to the integration of research and education and the education of a diverse engineering workforce that will be responsive to the needs of industrial and service enterprises.

The DMII Division's academic research programs are grouped into the following two clusters:

- **Engineering Decision Systems**
- **Manufacturing Process and Equipment Systems**

The former focuses on the mathematical aspects of design, service, and enterprise systems; the latter addresses the physical aspects of materials and manufacturing processes.

DMII's Industrial Innovation Programs support small business and organizational innovation research, as well as programs that seek collaboration with industry. These programs are crosscutting and span all areas supported by the Engineering Directorate, as well as many other parts of NSF.

### ⓘ For More Information

Visit the DMII home page, http://www.eng.nsf.gov/dmii/; or contact by telephone, 703-292-8330, or by fax, 703-292-9056; or write to the Division of Design, Manufacture, and Industrial Innovation, National Science Foundation, 4201 Wilson Boulevard, Room 550, Arlington, VA 22230. We welcome personal visits as well.

## ENGINEERING DECISION SYSTEMS CLUSTER

The Engineering Decision Systems Cluster provides funding for fundamental research on theory and methods that guide and support decisions about the design and operation of products and enterprise systems. The programs are distinguished by their focus on methods that are

- founded in mathematics, statistics, decision sciences, economics, and information technology, as opposed to the natural and social sciences; and

- addressed to the prescriptive derivation of preferred choices, as opposed to descriptive characterization of scientific and engineering phenomena.

Much of the research is computational and/or exploits capabilities of the Internet, but development of commercial software or networks is not supported. Similarly, incorporation of the research into educational programs is encouraged, but supported projects must have significant research content.

This cluster of programs consists of the following:

1. **Engineering Design**
2. **Operations Research**
3. **Manufacturing Enterprise Systems**
4. **Service Enterprise Engineering**

### ⓘ For More Information

Visit the Engineering Decision Systems Cluster web site, http://www.eng.nsf.gov/dmii/EDS/eds.htm.

**1. Engineering Design (ED)—**Focuses on fundamental theory and general-purpose tools for conceptualization and description of engineered products and systems, including analysis of alternatives and selection of preferred choices. The program embraces a holistic view of design that recognizes that choices are best made in a total-system, life-cycle context. ED does not support the design of specific products or systems, but instead seeks novel advances in generic design theory and methodology.

**2. Operations Research (OR)—**Is concerned with generic tools for modeling and optimization of manufacturing and service enterprise operations. Emphasis is on research improving basic analytical and computational techniques, especially where their potential for impact on relevant engineering and operations management problems is apparent.

**3. Manufacturing Enterprise Systems (MES)—**Addresses research that is focused on design, planning, and control of operations in manufacturing enterprises, including the associated procurement and distribution supply chains. Contributions should extend the range of analytical and computational techniques addressed to these enterprise operations, and/or advance novel models that offer policy insight or the prospect of implementable solutions. Research in MES is typically performed with the guidance or collaboration of appropriate industrial partners.

**4. Service Enterprise Engineering (SEE)—**A new program intended to parallel MES with enhanced focus on enterprises in the commercial service sector. MES will be phased in, beginning in fiscal year 2002 (see the DMII web site for details). Contributions should extend the range of analytical and computational techniques addressed to service enterprise operations, and/or advance novel models offering policy insight or the prospect of implementable solutions. However, measurement and conceptualization of service processes as engineered systems may themselves represent a contribution in some applications. Research in SEE is typically performed with the guidance or collaboration of appropriate industrial partners.

## MANUFACTURING PROCESSES AND EQUIPMENT SYSTEMS CLUSTER

The manufacturing enterprise requires the integration of appropriate scientific, engineering, and mathematics disciplines with design objectives within a systems framework where the desired outcome is a viable product or service. Product realization, integrated product and process development (IPPD), and concurrent engineering are all aspects of the manufacturing enterprise. The drivers for the manufacturing enterprise are the economic, energy, and environmental issues that define viability in terms of cost, delivery, and performance. The major developments in manufacturing during the past 30 years include computer-integrated manufacturing; automation in robotics and flexible manufacturing systems for lean and agile manufacturing; artificial intelligence and Internet-based systems for distributed manufacturing; quality assurance; net shape processes; additive, layered, and beam processing including solid freeform fabrication and surface modification; and open-architecture manufacturing systems. However, research is needed in order to make macro-, meso-, micro-, and nanomanufacturing more productive, predictable, efficient, economical, environmentally benign, and globally competitive.

The goals of the Manufacturing Processes and Equipment Systems Cluster are

- to support research that will advance our understanding of the manufacturing processes, machine tools, and systems within the broad scope of unit manufacturing processes; and

- to bring about manufacturing innovations that have an impact on the economy and society.

The cluster emphasizes research that employs a blend of analytical, computational, and experimental efforts to address three key research issues: predictability, producibility, and productivity. These issues are key to enhancing performance, efficiency, quality, and reduction/elimination of adverse environmental effects in manufacturing to make U.S. industries globally competitive. There are three program elements under this cluster:

- **Manufacturing Machines and Equipment**

- **Materials Processing and Manufacturing**
- **Nanomanufacturing**

### ⓘ For More Information

Visit the Manufacturing Processes and Equipment Systems Cluster web site, http://www.eng.nsf.gov/dmii/MPES/mpes.htm.

**1. Manufacturing Machines and Equipment (MME)—**Focuses on generating the fundamental knowledge for building next-generation machines and equipment and their applications for materials processing, parts manufacture, assembly, inspection, and other operations. It supports theoretical and experimental research in mechanism, surface integrity, monitoring and control, metrology, part fixturing, environmental effects, performance, and productivity improvements related to micro-, meso-, and macromachining processes and manufacturing equipment.

**2. Materials Processing and Manufacturing (MPM)—**Supports the innovation of novel manufacturing processes and methodologies for making useful products from new and recycled materials through the understanding and control of the behavior of materials during processing. Typical research activities include the net shape processing of metals, ceramics, polymers, and composite materials. The program does not support research in the processing of semiconductor materials such as Si and GaAs.

**3. Nanomanufacturing (NM)—**Supports innovative, fundamental research in the science and technology of nanostructured materials, components, and systems, leading to potential breakthroughs in manufacturability of new industrial products or enabling useful services and new applications. Emphasis is on theoretical and experimental research that addresses the underlying necessities for predictability, producibility, and productivity in manufacturing at nanoscale.

## INDUSTRIAL INNOVATION PROGRAMS CLUSTER

The Industrial Innovation Programs address innovation opportunities for small businesses, as well as academic research on the innovation process itself. These programs provide opportunities for academic research to link with the industrial sector and include

- **Small Business Innovation Research (SBIR)**
- **Small Business Technology Transfer (STTR)**
- **Grant Opportunities for Academic Liaison with Industry (GOALI)**
- **Innovation and Organizational Change (IOC)**

### ⓘ For More Information

Visit the DMII home page, http://www.eng.nsf.gov/dmii/.

**1. Small Business Innovation Research (SBIR)—**Offers opportunities and incentives for creative small businesses that are involved in science, engineering, education, or technology to conduct innovative, high-risk research on important scientific and technical problems. Research supported by the SBIR Program should have significant potential for commercialization and public benefit. This three-phase program offers incentives for converting federally supported research carried out in Phases I and II into

commercial application in Phase III, which is funded by private capital.

**2. Small Business Technology Transfer (STTR)—**Links entrepreneurs with the academic research community and encourages commercialization of government-funded research by the private sector. Proposals submitted to the STTR Program must have small-business principal investigators, but up to 60 percent of STTR funding may be used to support university subcontracts necessary to assist in the commercialization of research products by the small business firm. STTR is a three-phase program that offers incentives for converting research done in Phases I and II to commercial application in Phase III, which is funded by private capital. The difference between SBIR and STTR is in the requirements for partnership of the small business sector with the academic community.

**3. Grant Opportunities for Academic Liaison with Industry (GOALI)—**This initiative aims to encourage industry/ university partnerships by making funds available for the support of an eclectic mix of industry/university linkages. Specifically, GOALI provides support (1) to conduct research and gain experience with production processes in an industrial setting; (2) for industry scientists and engineers to bring industry's perspective and integrative skills to academe; and (3) for interdisciplinary industry/university teams to conduct long-term projects. GOALI supports faculty, postdoctoral fellows, and students in developing creative modes of collaborative interaction with industry through individual or small-group projects, and supports industry-based fellowships for graduate students and postdoctoral fellows. The GOALI Initiative targets high-risk and high-gain research that focuses on fundamental topics that would not have been undertaken by industry, and supports the development of innovative, collaborative, industry/university educational programs and the direct transfer of new knowledge between academe and industry.

**4. Innovation and Organizational Change (IOC)—**Seeks to improve the performance of industry, education, service, health care, government, and other organizations and institutions through the support of research on theories, concepts, and methodologies of innovation and organizational change. The Directorates for Engineering; Social, Behavioral, and Economic Sciences; and Education and Human Resources jointly support IOC. The program supports research that combines theory with empirical validation to understand effective approaches to organizational learning and redesign, strategic and cultural change, quality and process improvement, innovation, new product and service development, and development and integration of new technologies. Proposers should work with partner organizations in industry, education, health care, government, or service.

## DIVISION OF ELECTRICAL AND COMMUNICATIONS SYSTEMS

The Division of Electrical and Communi-cations Systems (ECS) addresses the fundamental research issues underlying both the device technologies and the engineering systems principles of complex systems and applications. It also seeks to ensure the education of a diverse workforce prepared to support the continued rapid development of these technologies as drivers of the global economy. The research and education supported by ECS are fundamental to developing synergy between micro- and nanotechnology, biotechnology,

and information technology in support of the emerging new industries and economy of the 21st century. The study of micro-electronic, nanoelectronic, micromagnetic, photonic, and microelectromechanical devices and their integration into circuits and microsystems is rapidly expanding in technical scope and applications. New generations of integrated microsystems incorporate microchip technology with mechanical, biological, chemical, and optical sensors, actuators, and signal processing devices to achieve new functionality. Modern computing and communications systems are based on these devices. Trends toward smaller devices raise new research challenges to fabricate molecular-based nanoscale structures and understand quantum principles, which dominate their behavior. Research on the design and analysis of systems and the convergence of control, communications, and computation forms the basis for new research directions in intelligent engineering systems. These systems, which learn new functions and adapt to changing environments, are especially important for advanced applications. The integration of device research and systems principles has broad applications in telecommunications, wireless networks, power and energy, environment, transportation, biomedicine, manufacturing, and other areas. ECS supports integrative research through opportunities whose themes encourage innovative and collaborative systems-oriented research. ECS also provides support for specialized resources and infrastructure that facilitate research and education activities.

The ECS Division supports the following programs and activities:

1. **Electronics, Photonics, and Device Technologies**
2. **Control, Networks, and Computational Intelligence**
3. **Integrative Systems**
4. **Resources and Infrastructure**

## For More Information

Write to the Division of Electrical and Communications Systems, National Science Foundation, 4201 Wilson Boulevard, Room 675, Arlington, VA 22230; or contact the division by telephone, 703-292-8339, or by fax, 703-292-9147; or visit the ECS home page, http://www.eng.nsf.gov/ecs/.

**1. Electronics, Photonics, and Device Technologies (EPDT)—**Seeks to improve the fundamental understanding of devices and components based on the principles of electronics, photonics, electromagnetics, electrooptics, electromechanics, and related physical phenomena and to enable the design of integrated microsystems that define new capabilities and applications. Experimental and theoretical studies of nanoscale electronic, spintronic, and photonic devices and principles, use of nanotechnology for device fabrication, and related topics in quantum and molecular engineering and quantum computing are of particular current interest. Adaptive and reconfigurable devices and low-power/low-noise electronics are used in novel network architectures and advanced communications systems. Microsensors and microactuators are used in diverse areas, ranging from industry and defense applications to biology and medicine. The program invites proposals for research that can lead to high performance of micro- and nanoscale devices, components, and materials; advanced methods of design, modeling, and simulation of devices and components; and improved techniques for processing, fabrication, and manufacturing.

**2. Control, Networks, and Computational Intelligence (CNCI) (formerly Knowledge Modeling and Computational Intelligence)—**Supports creative research underlying the analysis and design of intelligent engineering systems and

networks for control, communications, and computation. The program invites proposals for research that can lead to improved methods for analysis, design, optimization, and evaluation of complex systems. Distributed systems and networks occur in telecommunications, power and energy, and transportation systems. Hybrid systems incorporate both continuous and symbolic knowledge representation and are of increasing interest in the study of networks, manufacturing, and transportation systems. Adaptive, learning, and self-organizing principles offer potential for improved performance for systems with unknown models and changing characteristics, especially in biomedical and environmental applications. Biologically inspired methods and algorithms, including neural networks, evolutionary computation, behavioral architectures, and intelligent agents for engineering applications are also of interest. High-performance and domain-specific computation is applied to the development of simulation, design, and decision tools for engineering applications.

**3. Integrative Systems (IS)—**Stimulates innovative research in areas that integrate device concepts and systems principles to develop new technologies and new research directions. Proposals are sought that address fundamental research issues associated with the analysis and design of such integrative systems. Areas of opportunity are announced on the ECS home page. In addition, researchers are welcome to propose potential topics of interest and are encouraged to discuss them with a program director. An example of an integrated microsystem is a miniature implantable device that combines sensors, actuators, and computational algorithms and microcircuits for biomedical applications that range from drug delivery to microsurgery. A second example is a wireless network of handheld or wearable computing devices that incorporate microsystem transmitters, receivers, antennas, and sensors and constitute a complex distributed network with high bandwidth and high information-transfer requirements. Such integrative systems offer new challenges in basic research and promise for future applications. Proposals for integrative systems research may involve collaborative research among investigators in order to capture a breadth of expertise.

**4. Resources and Infrastructure—**In partnership with other NSF directorates and government agencies, provides nationwide research and education resources, including the National Nanofabrication Users Network. NSF's Science and Technology Centers, Engineering Research Centers, Industry/University Cooperative Research Centers, and Integrative Graduate Education and Research Traineeship Program affect many of the research areas of the ECS community. Researchers and educators are encouraged to build linkages with these facilities and fully utilize the infrastructure. ECS also seeks to enhance academic infrastructure through supplemental and special program opportunities and through the international collaborations described in the overview of the Engineering Directorate. In addition, ECS encourages the participation in the development of cross-disciplinary programs including industry-related and graduate traineeship programs.

## DIVISION OF ENGINEERING EDUCATION AND CENTERS

The Division of Engineering Education and Centers (EEC) supports centers that collaborate with industry to integrate

research and education and projects to promote innovations in engineering education and engage a diverse body of students in engineering research. These efforts integrate new knowledge across disciplines, accelerate technology development, and improve the capabilities and diversity of engineering graduates entering the technical workforce.

EEC's centers promote partnerships among researchers in different disciplines and between industry and universities. They focus on integrated engineered systems and produce technological innovations that strengthen the competitive position of industry. Their graduates are well-rounded, professionally oriented engineers with a global outlook, experience in technological innovation, and the ability to assume leadership roles in industry, academe, and government.

The educational innovation projects of EEC range from small-scale efforts that integrate research into curricula at the course level, to the development and implementation of large-scale models for engineering curriculum reform. These efforts have infused knowledge of emerging technology into curriculums across the country and have provided models for systemic reform of engineering curriculum that have included freshman-year experience with design and product development. All efforts promote the diversity of the engineering workforce.

The EEC Division supports the following programs and activities:

1. **Engineering Research Centers**
2. **Industry/University Cooperative Research Centers**
3. **Engineering Education**
4. **Combined Research–Curriculum Development**
5. **Supplemental Funding for Support of Women, Minorities, and Physically Disabled Engineering Research Assistants**

## ⓘ For More Information

Write to the Division of Engineering Education and Centers, National Science Foundation, 4201 Wilson Boulevard, Room 585, Arlington, VA 22230; or contact the division by telephone, 703-292-8380, or by fax, 703-292-9051; or visit the EEC home page, http://www.eng.nsf.gov/eec/.

**1. Engineering Research Centers (ERC's)—**Provide an integrated environment for academe and industry to focus on next-generation advances in complex engineered systems, with synergy among engineering, science, and industrial practice. ERC's integrate research and education at both the graduate and undergraduate levels and produce curriculum innovations derived from the engineering systems research focus of the ERC. ERCs build partnerships with industry, develop shared infrastructure, and increase the capacity of engineering and science graduates to contribute to U.S. competitiveness. They are supported for up to 10 years to promote the long-term perspective in engineering research and education that is required to produce new technologies and innovative products and services.

**2. Industry/University Cooperative Research Centers (I/UCRC's)—**Develop long-term partnerships among industry, academe, and government. The centers are university-based and catalyzed by a small investment from NSF but are primarily supported by industry members. I/UCRC's are led by faculty who have a strong desire to work with industry and who want to pursue fundamental research agendas recommended by industrial advisory boards. Center research projects are conducted primarily by graduate students; the program thus develops students who know how to

conduct industrially relevant research and communicate their findings effectively.

**3. Engineering Education Programs—** Stimulate innovation and reform in engineering education to produce graduates who are better able to serve the evolving needs of the new century. A high priority is developing high-quality engineering curricula that will attract and retain increased numbers of engineering students, especially women, underrepresented minorities, and people with disabilities.

The Action Agenda for Engineering Curriculum Innovation Program supports the implementation of new approaches to educate engineers and encourage outstanding students—particularly from underrepresented groups—to enter the field. The Action Agenda Program builds on successful innovations from the NSF Engineering Education Coalitions and other new concepts for the reform and improvement of engineering education, and seeks to involve research-active scholars more actively in education innovation.

EEC participates in NSF's Learning for the 21st Century Initiative, building on successes and experiences in the systemic reform of education in grades K–12. EEC also supports programs through which new faculty can learn from successful scholars and practitioners in such areas as learning theories, course and curriculum design, test construction and evaluation, multimedia technologies, student mentoring, diversity, and leadership.

**4. Combined Research–Curriculum Development Program—**Supports curriculum development projects that integrate new, state-of-the-art research advances in emerging technological areas into upper-level undergraduate and introductory graduate engineering and computer and information science curricula.

**5. Supplemental Funding for Support of Women, Minorities, and Physically Disabled Engineering Research Assistants—**Provides supplemental funding to include women, under-epresented minorities, and physically disabled undergraduate or high school students as research assistants on funded projects. Supplemental funding of up to $5,000, including indirect costs, may be requested for each student added to the project. Funds provided by this program are limited to two students per grant. Up to 10 percent of this amount may be used for supplies and services. The support may be used for a summer, a quarter, or an academic year.

If necessary, additional funds in excess of $5,000 may be requested to provide special equipment or modify existing equipment, or to provide other services specifically for the purpose of enabling a physically disabled person (or persons) to participate. The equipment must be directly related to the research work, such as a prosthetic device to manipulate a specific piece of equipment, and not for general assistance, such as wheelchairs or ramps.

# GEOSCIENCES

Research in the Directorate for Geosciences (GEO) seeks to advance the state of knowledge about the Earth, including its atmosphere, continents, oceans, interior, and Sun, and the processes that modify and link them together.

The Directorate for Geosciences supports programs and activities through the following:

- **Crosscutting Programs and Activities**
- **Education and Outreach Activities**
- **Division of Atmospheric Sciences (ATM)**
- **Division of Earth Sciences (EAR)**
- **Division of Ocean Sciences (OCE)**

## ⓘ For More Information

Visit the GEO Directorate home page, http://www.geo.nsf.gov/.

# CROSSCUTTING PROGRAMS AND ACTIVITIES

In addition to the programs mentioned in this section, the Directorate for Geosciences takes an active role in the following crosscutting programs and activities:

- **Environment and Global Change, including the Inter-American Institute for Global Change Research**
- **Information Technology Research**
- **Biocomplexity in the Environment**
- **Nanoscale Science and Engineering**
- **Learning for the 21st Century**
- **Experimental Program to Stimulate Competitive Research (EPSCoR)**
- **Earth System History (ESH)**
- **Graduate Teaching Fellows in K–12 Education (GK–12)**
- **Grant Opportunities for Academic Liaison with Industry (GOALI)**
- **Major Research Instrumentation (MRI)**
- **Partnerships for Innovation (PFI)**
- **Science and Technology Centers (STC's): Integrative Partnerships**

### ⓘ For More Information

Visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm/start.htm .

# EDUCATION AND OUTREACH ACTIVITIES

### Global Learning and Observations to Benefit the Environment

In addition to the discipline-specific education and outreach activities supported by the Directorate for Geosciences, the directorate participates in the multiagency Global Learning and Observations to Benefit the Environment (GLOBE) Program. GLOBE is a developing international effort that links scientists and schoolchildren through a global information network. It is designed to promote general science literacy related to environmental and global change issues.

### ⓘ For More Information

Visit the GLOBE Program web site, http://www.globe.gov/. For information about GLOBE activities within NSF, contact the GLOBE Program Director in the Directorate for Geosciences by telephone, 703-292-7858, or by e-mail, globe@nsf.gov, or visit the GEO Directorate home page, http://www.geo.nsf.gov/; or the Education and Human Resources (EHR) Directorate home page, http://www.ehr.nsf.gov/. Additional information about programs in the EHR Directorate can also be found in the EHR section of this Guide.

### Geosciences Education Program

The Geosciences Education Program (formerly titled Awards to Facilitate Geoscience Education or AFGE) program announcement is issued annually. The intent of the program is to support geoscience education activities that integrate geoscience research and

education and lead to improvements in the quality of geoscience education. Proposals at all education levels are encouraged. Abstracts of previous awards are available at http://www.geo.nsf.gov/adgeo/education.htm

**For More Information**

Contact Ms. Jewel Prendeville by e-mail, jprendev@nsf.gov; or visit the GEO Directorate home page, http://www.geo.nsf.gov.

### Opportunities for Enhancing Diversity in the Geosciences

The program for Opportunities for Enhancing Diversity in the Geosciences (OEDG) is part of the Directorate for Geosciences' effort to broaden the participation of groups traditionally underrepresented in the geosciences, including women, minorities, and persons with disabilities. The activity was implemented in fiscal year 2001, and program announcements are expected to be released annually.

**For More Information**

Visit the GEO Directorate home page, http://www.geo.nsf.gov/geo/diversity/. Suggestions and comments related to this new effort can be sent to geo_diversity@nsf.gov.

### Other Programs and Activities

In addition to the programs and activities mentioned here, the GEO Directorate participates in the following NSF-wide education and outreach activities:

- Faculty Early Career Development (CAREER)
- Integrative Graduate Education and Research Training (IGERT)
- Minority Research Planning Grants and Minority Career Advancement Awards (MRPG/MCAA)
- Presidential Early Career Awards for Scientists and Engineers (PECASE)
- Research Experiences for Undergraduates (REU)
- Research in Undergraduate Institutions and Research Opportunity Awards (RUI/ROA)

**For More Information**

Visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm/start.htm .

## DIVISION OF ATMOSPHERIC SCIENCES

The Division of Atmospheric Sciences (ATM) supports research to increase understanding of the behavior of Earth's atmosphere and its interactions with the Sun. Included are studies of the physics, chemistry, and dynamics of Earth's upper and lower atmospheres and its space environment; research on climate processes and variations; and studies to understand the natural global cycles of gases and particles in Earth's atmosphere. NSF also provides support for participation by the U.S. scientific community in international scientific research endeavors, such as the World Climate Research Program.

The ATM Division supports the following programs and activities:

- **Lower Atmosphere Research**
- **Upper Atmosphere Research**
- **Centers and Facilities**

**Submission of Proposals to ATM**

Proposals may be submitted at any time during the year for all programs in the ATM Division except special programs such as Earth System History (ESH); Coupling, Energetics, and Dynamics of Atmospheric Regions (CEDAR); Geospace Environmental Modeling (GEM); and those involving the allocation of observational and computing facilities. Proposals should be submitted to the appropriate NSF program and should follow the guidelines printed in the NSF *Grant Proposal Guide* (see http://www.nsf.gov/cgi-bin/getpub?gpg for latest version). For projects that propose the use of lower atmospheric observing facilities and/or computing resources, a facility request also is required. A facility request should be sent to the manager of each facility where the proposed work would take place. Procedures for requesting the use of a facility are established by the institution managing the facility. It is important for institutions submitting a request to seek advice from the Lower Atmospheric Observing Facilities manager at NSF. Those submitting facility requests requiring in excess of $500,000 in deployment costs are required to submit a preproposal to NSF 4 months before the actual deadline for submission of proposals.

Any questions on the use of computing resources should be directed to the Director, Scientific Computing Division (SCD), National Center for Atmospheric Research (NCAR), P.O. Box 3000, Boulder, CO 80307; or visit the SCD web site, http://www.scd.ucar.edu/, located on the NCAR home page.

**ⓘ For More Information**

Write to the Division of Atmospheric Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 775, Arlington, VA 22230; or contact the division by telephone, 703-292-8520; or visit the ATM Division home page, http://www.geo.nsf.gov/atm/.

## LOWER ATMOSPHERE RESEARCH

The following programs make up the Lower Atmosphere Research Section. For complete information, visit the Lower Atmosphere Research Section web site, http://www.geo.nsf.gov/atm/lower.htm.

1. **Atmospheric Chemistry**
2. **Climate Dynamics**
3. **Large-Scale Dynamic Meteorology**
4. **Mesoscale Dynamic Meteorology**
5. **Paleoclimate**
6. **Physical Meteorology**

**1. Atmospheric Chemistry—**Supports research to measure and model the concentration and distribution of gases and aerosols in the lower and middle atmosphere. The program also supports research on the chemical reactions among atmospheric species; the sources and sinks of important trace gases and aerosols; aqueous-phase atmospheric chemistry; the transport of gases and aerosols throughout the atmosphere; and improved methods for measuring the concentrations of trace species and their fluxes into and out of the atmosphere.

**2. Climate Dynamics—**Supports research on the processes that govern climate and the causes of climate variability and change; methods to predict climate variations; the assembly and analysis of modern climatic data; and the development and use of climate models to diagnose and simulate climate and its variations and changes.

**3. Large-Scale Dynamic Meteorology—**Supports basic research to improve the understanding and prediction of atmospheric motion on a scale from

synoptic to planetary. Research topics include general circulation of the troposphere and stratosphere; synoptic-scale weather phenomena; atmospheric predictability; and improved parameterization of physical processes and numerical methods for use in large-scale models.

**4. Mesoscale Dynamic Meteorology—** Supports research on all aspects of mesoscale meteorological phenomena, including studies of the morphological, thermodynamic, and kinematic structure of mesoscale systems; the development of mesoscale systems and precipitation processes; and the energy transfer between scales.

**5. Paleoclimate—**Supports research on the natural evolution of Earth's climate with the goal of providing a baseline for present variability and future trends through improved understanding of the physical, chemical, and biological processes that influence climate over the long term.

**6. Physical Meteorology—**Supports basic research on the physics of the atmosphere with emphasis on cloud and precipitation physics; the transfer of solar and terrestrial radiation; atmospheric measurements, including active and passive remote sensing; and atmospheric electricity and acoustics. The program also supports research in micrometeorology, particularly turbulence, boundary-layer processes, and wave phenomena.

## UPPER ATMOSPHERE RESEARCH

The following programs make up the Upper Atmosphere Research Section. For complete information, visit the Upper Atmosphere Research Section web site, http://www.geo.nsf.gov/atm/upper.htm.

1. **Aeronomy**
2. **Magnetospheric Physics**
3. **Solar-Terrestrial**

**1. Aeronomy—**Supports research on upper and middle atmosphere phenomena of ionization, recombination, chemical reaction, photoemission, and transport; the transport of energy, momentum, and mass in the mesosphere/thermosphere/ ionosphere system, including the processes involved and the coupling of this global system to the stratosphere below and magnetosphere above; and the plasma physics of phenomena manifested in the coupled ionosphere/magnetosphere system, including the effects of high-power radio wave modification.

**2. Magnetospheric Physics—**Supports research on the magnetized plasma envelope of the outer atmosphere, including energization by solar wind; the origin of geomagnetic storms and substorms; the population by solar and ionospheric sources; the origin of electric fields; the coupling among the magnetosphere, ionosphere, and atmosphere; and the waves and instabilities in the natural plasma. Also supported are ground-based observational programs at high latitudes. Theoretical research programs may include numerical simulations using a variety of magnetohydrodynamics, hybrid, and particle codes. The analysis of data from all sources, whether ground-based or from spacecraft, is also supported.

**3. Solar-Terrestrial—**Supports research on the processes by which energy in diverse forms is generated by the Sun, transported to the Earth, and ultimately deposited in the terrestrial environment. Major topics include helioseismology; the solar dynamo; the activity cycle; the magnetic flux emergence; solar flares and

activity; coronal mass ejections; solar wind heating; interactions with cosmic rays; and solar wind/magnetosphere boundary problems. Studies on terrestrial influences include solar spectral irradiance changes; solar "constant" changes and climatic impacts; C14 and Sun/climate connections; and solar activity and its effects on the terrestrial environment of various time scales.

## CENTERS AND FACILITIES

1. **Lower Atmospheric Observing Facilities**
2. **Upper Atmospheric Facilities**
3. **National Center for Atmospheric Research**
4. **UNIDATA**

**1. Lower Atmospheric Observing Facilities (LAOF)—**The LAOF Program supports multiuser national research facilities that offer educational opportunities and serve the observational needs of the atmospheric science research community. These facilities include the following:

- **Aircraft—**Located at the National Center for Atmospheric Research (NCAR), a four-engine Lockheed EC-130Q Hercules; at the University of Wyoming, a Beech King Air; and at the South Dakota School of Mines and Technology, an armored T-28. These aircraft can be equipped with sensors to measure meteorological and chemical state parameters. A variety of instruments can be selected for a particular project, or users may supply specialized instrumentation.

- **Radar—**NCAR operates an airborne X-band—a dual-beam, rapid-conical-scanning, multiple-frequency radar—and a transportable multiparameter S/X-band Doppler radar. Colorado State University (CSU) operates a transportable CSU S-band radar that provides two complete transmit and receive channels.

- **Other Facilities—**NCAR operates surface-observing systems that measure surface fluxes of trace chemical species, water vapor, sensible heat, and momentum. NCAR also operates a network of surface meteorology stations that measure wind, temperature, humidity, pressure, solar radiation, and precipitation.

NCAR also provides a number of systems that measure the vertical profile of temperature, moisture, pressure, and winds in the troposphere.

### Eligibility Requirements for LAOF Proposals

LAOF are available on a competitive basis to all qualified scientists. Use of LAOF is based on the scientific merit of the research proposed, the capabilities of the facilities to carry out the proposed observations, and the availability of the facility during the requested time.

### ⓘ For More Information

Write to the following or visit the corresponding home pages:

- Division Director, Atmospheric Technology Division, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307-3000; or visit the ATD web site, http://www.atd.ucar.edu.

- Facility Manager, Wyoming King Air, Department of Atmospheric Science, P.O. Box 3038, University Station, Laramie, WY 82071.

- Facility Manager, T-28, Institute of Atmospheric Sciences (IAS), South Dakota

School of Mines and Technology, Rapid City, SD 57701; or visit the IAS research aircraft web site, http://www.ias.sdsmt.edu/institute/t28/index.htm.

- Facility Manager, CSU-CHILL Radar, Department of Atmospheric Sciences, Colorado State University, Fort Collins, CO 80523; or visit the CSU-CHILL web site, http://chill.colostate.edu/.

**2. Upper Atmospheric Facilities (UAF)—** NSF supports four large incoherent-scatter radar multiuser facilities located along a longitudinal chain from Greenland to Peru. Each facility is also equipped with powerful optical diagnostic instruments. In response to a need for more understanding of global-scale thermospheric and ionospheric problems, these facilities have been upgraded and realigned into a chain extending from the edge of the polar cap to the magnetic equator.

The major goal of the UAF Program is to promote basic research on the structure and dynamics of the Earth's upper atmosphere. Research is supported through the following activities:

- **Sondrestrom Research Facility—** Located in Sondre Stromfjord, Greenland, this facility is operated by SRI International under cooperative agreement with NSF. The facility allows observations on the edge of the polar cap, the cusp, and the northern part of the auroral oval.

- **Millstone Hill Radar—**Located near Boston, MA, and operated by the Massachusetts Institute of Technology under a cooperative agreement with NSF, this facility is south of the auroral oval in a region where significant mid-latitude phenomena are observed. The radar provides observations of high-altitude regions from almost directly above the radar in Sondre Stromfjord to almost directly above the next radar in the chain at Arecibo, Puerto Rico.

- **Arecibo Observatory—**Located in Arecibo, Puerto Rico, this observatory is operated by Cornell University's National Astronomy and Ionosphere Center under cooperative agreement with NSF. At Arecibo's latitude, scientists have obtained evidence of particle precipitation in the atmosphere; composition changes in the atmosphere after magnetic storms; gravity waves propagating from the auroral region; and the penetration of magnetospheric electric fields. The UAF Program also supports the high-frequency heating facility near the observatory.

- **Jicamarca Radio Observatory—** Located at the magnetic equator in Jicamarca, Peru, this observatory is owned by the Instituto Geofisico de Peru. Through a cooperative agreement with Cornell University, NSF acts as the principal sponsor of the facility, which provides a subcontract to the Institute.

### Eligibility Requirements for UAF Proposals

UAF facilities are available on a competitive basis to all qualified scientists. Use is based on the scientific merit of the proposed research, the capabilities of the radar to carry out the proposed observations, and the availability of the facility during the requested time.

### ⓘ For More Information

Write to the following addresses or visit the corresponding home pages:

- Director, Sondrestrom Research Facility, Radio Physics Laboratory, SRI International, Menlo Park, CA 94025; or visit the facility web site, http://isr.sri.com/.

- Director, Millstone Hill Radar, MIT, Haystack Observatory, Westford, MA 01886; or visit the facility web site, http://hyperion.haystack.edu/.

- Director, NAIC for Arecibo Observatory, Cornell University, Ithaca, NY 14853; or visit the NAIC web site, http://www.naic.edu/.

- Jicamarca Radio Observatory Project, Department of Electrical Engineering, Cornell University, Ithaca, NY 14853; or visit the observatory web sites, http://www.ee.cornell.edu/~spp/radar/jro/jicamarca.html or http://jro.igp.gob.pe/jro.html.

**3. National Center for Atmospheric Research—**The National Center for Atmospheric Research (NCAR) in Boulder, CO, is a focal point for research in the field of atmospheric and related sciences.

NCAR is supported by NSF and managed under a cooperative agreement between NSF and the University Corporation for Atmospheric Research, a nonprofit consortium of North American universities with graduate programs in atmospheric sciences.

The facilities at NCAR serve the entire atmospheric sciences research community and part of the ocean science community. Facilities include a computing and data center that provides supercomputer resources and services for the development and production of large models and for archiving, manipulating, and visualizing large data sets. For information on other NCAR facilities, see "Lower Atmospheric Observing Facilities," above.

NCAR's scientific research programs focus on subjects such as large-scale atmospheric and ocean dynamics; global and regional atmospheric chemistry; the variable nature of the Sun and the physics of the corona; the physics of clouds, thunderstorms, and precipitation formation and their interactions and effects on larger scale weather; and human society's impact on and response to global environmental change. NCAR also provides fellowships for visiting scientists to conduct research and interact with NCAR scientists.

**Eligibility Requirements for NCAR Proposals**

Support for facilities and visiting scientists is provided on a competitive basis to qualified scientists according to scientific merit, the availability of facility time, and the level of resources.

**ⓘ For More Information**

Write to the Director, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307; or visit the NCAR home page, http://www.ncar.ucar.edu/.

**4. UNIDATA—**UNIDATA is a national program to help universities access, analyze, and display a wide range of atmospheric data on their own computers, often in real time. The program is managed by UCAR and is supported by NSF's Division of Atmospheric Sciences. UNIDATA serves a broad community, including teaching and research professionals in weather forecasting, climate studies, atmospheric analysis and modeling, and related disciplines.

**ⓘ For More Information**

Visit the UNIDATA home page, http://www.unidata.ucar.edu/.

# DIVISION OF EARTH SCIENCES

The Division of Earth Sciences (EAR) supports research and education in most areas of the solid-earth and surficial-terrestrial sciences. Emphasis is on the support of basic research aimed at improving our understanding of the Earth's structure, composition, natural processes, evolution, paleobiology, and interactions with the Earth's biosphere, atmosphere, and hydrosphere. In addition, EAR provides support for instrumental and observational infrastructure and encourages innovative educational activities in the earth sciences.

The research programs and activities in the EAR Division are organized into two areas:

- **Core Research**
- **Special Emphasis**

The Core Research section supports research in the following areas: the solid Earth, with emphasis on our understanding of the Earth's dynamic behavior and structure; surficial-terrestrial research, which deals with processes related to the Earth's environmental envelope and near-surface phenomena; and instrumentation and facilities and education, which focuses on the development and acquisition of instrumentation for the research community and educational aspects of the earth sciences.

The Special Emphasis section includes research directed toward special scientific opportunities or that accommodates the changing needs of the scientific community. This research is often interdisciplinary or multidisciplinary in character, or focuses on newly emerging areas of the earth sciences.

**ⓘ For More Information**

Write to the Division of Earth Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 785, Arlington, VA 22230; or contact by telephone, 703-292-8550; or visit the EAR Division home page, http://www.geo.nsf.gov/ear/.

## CORE RESEARCH SUPPORT PROGRAMS

The Division of Earth Sciences supports fundamental research through programmatic discipline, as well as interdisciplinary and multidisciplinary proposals that may involve one or more disciplines. Especially welcome are proposals for research in newly emerging areas of science that may not fit easily into one of the program categories.

The following programs make up the Core Research Support in the EAR Division. The titles of these programs indicate in general terms the subject matter covered by each and should be taken in the broadest sense and not necessarily restricted to their specified discipline of science.

1. **Continental Dynamics**
2. **Education and Human Resources**
3. **Geology and Paleontology**
4. **Geophysics**
5. **Hydrologic Sciences**
6. **Instrumentation and Facilities**
7. **Petrology and Geochemistry**
8. **Tectonics**

**1. Continental Dynamics—**Supports multidisciplinary research that will result in a better understanding of the processes that govern the origin, structure, composition, and dynamic evolution of the continents and continental building blocks. This program is especially geared toward projects whose scope and complexity require a cooperative or multi-institutional approach and multiyear

planning and execution. The program is intended to fund only relatively large projects that do not fit easily within other EAR programs and that offer broad support for major sections of the earth sciences community. The program also funds research as part of the International Continental Scientific Drilling Program.

**For More Information**

Contact the program by telephone, 703-292-8559; or visit the EAR Division home page, http://www.geo.nsf.gov/ear/.

**2. Education and Human Resources—** Coordinates the division's efforts to improve earth science education for U.S. citizens and provides a liaison between the earth sciences research community and NSF's Directorate for Education and Human Resources. The program supports EAR's participation in NSF-wide programs such as Research Experiences for Undergraduates Sites.

**For More Information**

Contact the program by telephone, 703-292-8557; or visit the EAR Division home page, http://www.geo.nsf.gov/ear/.

**3. Geology and Paleontology—**Supports studies directed toward a better understanding of physical, chemical, geological, and biological processes at or near the Earth's surface and the landforms, sediments, fossils, low-temperature fluids, and sedimentary rocks that they produce. Areas of research may include paleontology, paleoecology, stratigraphy, paleoclimatology, geomorphology, glacial geology, sedimentology, soil genesis, sedimentary petrology, diagenesis, and organic geochemistry and biogeochemical cycles.

**For More Information**

Contact the program by telephone, 703-292-8551; or visit the EAR Division home page, http://www.geo.nsf.gov/ear/

**4. Geophysics—**Supports laboratory, field, theoretical, and computational studies related to the composition, structure, and processes of the Earth's interior. Topics include studies in seismicity and seismic wave propagation; the nature and occurrence of earthquakes; and the Earth's magnetic, gravity, and electrical fields and its internal temperature distribution. Support also is provided for geophysical studies of active deformation, including global-positioning-system-based geodesy, and fundamental laboratory studies of properties and behavior of earth materials in support of geophysical observation and theory.

**For More Information**

Contact the program by telephone, 703-292-8556; or visit the EAR Division home page, http://www.geo.nsf.gov/ear/.

**5. Hydrologic Sciences—**Supports basic research dealing with the Earth's hydrologic cycle and the role of water on and near the continental surfaces of the Earth. The program views hydrologic sciences as a geoscience interactive on a wide range of space and time scales with ocean, atmospheric, and solid earth sciences as well as plant and animal sciences. Supported projects may involve water in the form of precipitation, lakes, streams, and groundwater, and interactions with landforms, soils, the atmosphere, the biosphere, and the Earth's crust. The program encourages integrated studies of water balance and fluxes among the various reservoirs.

### ⓘ For More Information

Contact the program by telephone, 703-292-8549; or visit the EAR Division home page, http://www.geo.nsf.gov/ear/.

**6. Instrumentation and Facilities—** Supports the acquisition or upgrade of equipment required for research, the development of new instrumentation and techniques that extend current research capabilities in the earth sciences, the operation of multiuser regional or national facilities that provide access to complex and expensive instrument or database systems for a significant segment of the earth sciences research community, and the funding of research technicians.

### ⓘ For More Information

Contact the program by telephone, 703-292-8558; or visit the EAR Division home page, http://www.geo.nsf.gov/ear/.

**7. Petrology and Geochemistry—** Supports research on igneous, metamorphic, and hydrothermal processes that occur within the Earth and other planetary bodies and on the minerals, rocks, fluids, and ore deposits resulting from these processes. Included are studies in mineralogy, crystallography, petrology, volcanology, geochemistry, and economic geology. Supported research includes field, laboratory, theoretical, and computational studies.

### ⓘ For More Information

Contact the program by telephone, 703-292-8554; or visit the EAR Division home page, http://www.geo.nsf.gov/ear/.

**8. Tectonics—**Involves studies in structural geology, tectonics, geochronology, petrology, paleomagnetics, and other fields related to understanding the tectonic history of the lithosphere through time. Supported research includes field, laboratory, and theoretical studies of the processes and kinematics accompanying deformation at plate boundaries and in plate interiors.

### ⓘ For More Information

Contact the program by telephone, 703-292-8552; or visit the EAR Division home page, http://www.geo.nsf.gov/ear/.

## SPECIAL EMPHASIS AREAS

Certain research areas within the Division of Earth Sciences may be selected for emphasis on the basis of special scientific opportunities. Frequently, these opportunities are related to areas of national priority such as the environment, the U.S. Global Change Research Program, and the National Earthquake Hazard Reduction Program.

### ⓘ For More Information

The following is a list of Special Emphasis Areas in the EAR Division. Further information on any of the programs listed can be found in the corresponding program announcement listed (if available), or on the EAR Division home page, http://www.geo.nsf.gov/ear/.

- Cooperative Studies of the Earth's Deep Interior (CSEDI) (NSF 95-155)
- Earth System History (NSF 00-11)
- Environmental Geochemistry and Biogeochemistry
- Fundamental Earthquake Studies of the National Earthquake Hazard Reduction Program (NEHRP) (NSF 92-93)
- Water and Energy: Atmospheric, Vegetative, and Earth (WEAVE) Interactions

# DIVISION OF OCEAN SCIENCES

The Division of Ocean Sciences (OCE) supports basic research and education to further understanding of all aspects of the global oceans and their interactions with the Earth and the atmosphere. OCE also supports the operation, acquisition, construction, and conversion of major shared-use oceanographic facilities needed to carry out oceanographic-related research programs.

OCE supports research through the following sections:

- **Ocean Section**
- **Marine Geosciences Section**
- **Integrative Programs Section**

At any given time, certain research areas within the OCE Division may be selected for emphasis on the basis of special scientific opportunities. Further information on global change research programs and other focused programs is available on the OCE Division home page, http://www.geo.nsf.gov/oce/.

### ⓘ For More Information

For further information, including deadline and target dates, extended program descriptions, and publications, write to the Division of Ocean Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 725, Arlington, VA 22230; or contact the division by telephone, 703-292-8580; or visit the OCE Division home page, http://www.geo.nsf.gov/oce/.

## OCEAN SECTION

The Ocean Section of the Division of Ocean Sciences funds projects dealing with the disciplinary sciences of biological, chemical, and physical processes in the ocean. The Ocean Section is composed of the following programs:

1. **Biological Oceanography**
2. **Chemical Oceanography**
3. **Physical Oceanography**

In addition to these regular programs, there are occasional announcements of opportunity to participate in global change research programs and other initiatives.

### ⓘ For More Information

Write to the Ocean Section, Division of Ocean Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 725, Arlington, VA 22230; or contact the division by telephone, 703-292-8582; or visit the OCE Division home page, http://www.geo.nsf.gov/oce/.

**1. Biological Oceanography—**Supports research on ocean productivity; the distribution, abundance, physiology, and life history of pelagic, coastal, and deep-sea marine organisms and their interactions with environments; structures of pelagic and benthic food chains; primary and secondary production; interactions between deep-sea biological processes and the ocean ecosystem; the specialization of deep-sea organisms; the ecology of the Great Lakes and factors regulating productivity; and marine biotechnology.

**2. Chemical Oceanography—**Supports research on physical and chemical properties of seawater, including kinetic and thermodynamic equilibria of chemical

species and compounds in seawater; fluxes between seafloor sediments, their interstitial waters, and overlying seawater; fates of materials deposited on the seafloor; alterations and interactions of material moving through the ocean; interactions and interdependencies between chemical processes and marine organisms; air-sea exchanges of manmade and naturally mobilized chemicals; and chemical properties of the ocean surface.

**3. Physical Oceanography—**Supports research on the description, analysis, and modeling of oceanic circulation and transport; the effects of circulation on energy and momentum transport; physical circulation processes, eddy generation, and turbulent mixing on continental shelves; mixing processes and circulation in estuaries; wind-generated tides and surface and internal waves; small-scale transport processes such as diffusion, conduction, convection, and three-dimensional turbulence; and physical properties of seawater and circulation and mixing processes in lakes.

## MARINE GEOSCIENCES SECTION

The Marine Geosciences Section supports research on processes that occur on and below the seafloor and at the water/sediment/rock interface. The section also supports facilities dedicated to such research. The Section is composed of the following programs:

1. **Marine Geology and Geophysics**
2. **Ocean Drilling Program**

### ⓘ For More Information

Write to the Marine Geosciences Section, Division of Ocean Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 725, Arlington, VA 22230; or contact the program by telephone, 703-292-8581; or visit the OCE Division home page, http://www.geo.nsf.gov/oce/.

**1. Marine Geology and Geophysics—**Supports research on the structure of continental margins, oceanic rise systems, and deep-sea sedimentary basins; the evolution of ocean basins; processes controlling exchanges of heat and chemical elements between seawater and oceanic rocks; tectonic and volcanic activity at mid-ocean ridges; chemical and mineralogic variations in marine sediments; the deposition, erosion, and distribution of marine sediments; geologic and oceanographic processes controlling sedimentary systems; past oceanic circulation patterns and climates; the evolution of microfossil groups; paleoenvironmental controls on fossil groups and sediment types; and interactions of continental and oceanic geologic processes.

**2. Ocean Drilling Program (ODP)—**Explores, on a global scale, the Earth's crust beneath the ocean in order to learn more about the composition, structure, and history of the submerged portion of the Earth's surface. The drilling process involves collecting and logging geologic samples from the floor of deep ocean basins through rotary coring and hydraulic piston coring. The logs and samples of the cores are available to qualified scientists throughout the world for research projects.

- **ODP Operations—**The drilling program has taken samples at various sites, including the North Atlantic Ocean, Norwegian Sea, Mediterranean Sea, southern and equatorial Atlantic Ocean, Pacific Ocean off the west coast of South America, Weddell Sea off Antarctica, Indian Ocean, and western and equatorial Pacific Ocean.

The general contractor for the overall management and operation of the ODP is Joint Oceanographic Institutions, Inc. (JOI), a consortium of major U.S. oceanographic institutions. The drilling operations are managed by Texas A&M University; logging is managed by the Lamont-Doherty Earth Observatory at Columbia University.

- **U.S. Science Support—**NSF provides funding for the participation of and drilling-related research performed by U.S. scientists. Activities include investigations of potential drilling regions, especially by means of regional geophysical field studies; the feasibility and initial development of downhole instruments and techniques; and downhole geophysical and geochemical experiments.

In addition, NSF will consider proposals for studies that lead to a long-range definition of future drilling objectives. To be considered for support, proposed projects should be clearly relevant to the drilling plans of the international drilling community and focus on predrilling or drilling-concurrent activities. Postcruise studies should generally be submitted through other appropriate NSF programs in the areas of ocean and earth sciences and polar programs.

Additional support for U.S. scientists may be obtained through the JOI U.S. Science Advisory Committee (JOI-USSAC). This NSF-sponsored program consists of planning activities, such as workshops, to define concepts and develop problem-related drilling programs, including U.S. participation in Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES); support for U.S. scientists participating on the drill ship; and support for necessary followup studies related to initial publication of drilling results.

In addition, requests for proposals may be issued for other surveys, regional and topical syntheses of existing data, and the development of downhole tools and instrumentation as these tasks are identified.

**Other Pertinent Information Regarding ODP**

Proposals for drilling specific sites should be submitted to the JOIDES Planning Committee Chairman, c/o Joint Oceanographic Institutions, Inc., 1755 Massachusetts Avenue, NW, Suite 800, Washington, DC 20036; or contact by telephone, 202-232-3900.

Applications for scientific participation aboard a ship should be submitted to the Manager of Science Operations, Ocean Drilling Program, Texas A&M University, College Station, TX 77843-3469. Appropriate support may be provided by JOI-USSAC.

Submit requests for data and samples of core material to the Curator, Ocean Drilling Program, Texas A&M University, College Station, TX 77843-3469; or visit the ODP home page, http://www-odp.tamu.edu/curation/.

For information on logs and the logging program, write to the Borehole Research Group, Lamont-Doherty Earth Observatory, Palisades, NY 10964; or visit the group's home page, http://www.oceandrilling.org.

Proposals for planning activities and workshops may be submitted to the JOI-USSAC Chairman, c/o Joint Oceanographic Institutions, Inc., 1755 Massachusetts Avenue, NW, Suite 800, Washington, DC 20036.

## INTEGRATIVE PROGRAMS SECTION

The Integrative Programs Section supports activities and facilities necessary for NSF-

funded research and training of oceanographers across disciplines. Examples of research and training support include technology development and dedicated educational activities. Facilities supported include ships, submersibles, large shipboard equipment, and shared-use instruments to collect and analyze data. The University-National Oceanographic Laboratory System (UNOLS) schedules these facilities and expeditionary programs.

1. **Oceanographic Facilities**
   - **–Ship Operations**
   - **–Oceanographic Instrumentation**
   - **–Oceanographic Technical Services**
   - **–Shipboard Scientific Acquisitions and Upgrades**
2. **Oceanographic Technology and Interdisciplinary Coordination**
3. **Educational Opportunities**

## ⓘ For More Information

Write to the Integrative Programs Section, Division of Ocean Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 725, Arlington, VA 22230; or contact the section by telephone, 703-292-8583; or visit the OCE Division home page, http://www.geo.nsf.gov/oce/.

**1. Oceanographic Facilities (Ship Operations, Oceanographic Instrumentation, Technical Services, and Shipboard Scientific Acquisitions and Upgrades)—**Support for major oceanographic facilities is concentrated at institutions that have substantial research programs in oceanography and also support the research projects of other institutions. Before submitting a proposal for support in these areas, institutions should seek advice from the relevant program officer. Specific instructions on how to submit proposals can be found in the publication *Division of Ocean Sciences (OCE): Proposal Submission Deadlines for Research Ship Operations, Instrumentation and Equipment, and Technical Services Support* (NSF 00-39).

**2. Oceanographic Technology and Interdisciplinary Coordination—**Supports a wide range of multidisciplinary activities that broadly seek to develop, transfer, or apply instrumentation and technologies that will benefit research programs supported by NSF, and also enhance the conduct of basic ocean sciences research. Instrumentation and technology projects supported by this program must be broadly usable and be of benefit to more than just one particular research project. The scope of projects varies from short-term feasibility studies to the development, construction, and at-sea testing of a prototype to demonstrate that useful and applicable data can be obtained using it. If ocean research is to be undertaken, joint consideration with the relevant research program may be conducted for the instrument development phase of the project. In addition, the Interdisciplinary Coordination Program area supports a limited number of research approaches that cross the four basic ocean science subdisciplines (physics, chemistry, biology, and geology and geophysics).

**3. Educational Opportunities—**Provides support for programs, many of them agency-wide, emphasizing educational opportunities at all levels.

# MATHEMATICAL AND PHYSICAL SCIENCES

The programs in the Directorate for Mathematical and Physical Sciences (MPS) are designed to increase the knowledge base in mathematical and physical sciences, improve the quality of education in mathematical and physical sciences in graduate and undergraduate activities, increase the rate at which advances in mathematical and physical sciences are translated into advances in science and technology on a broad spectrum and into societal benefits, and increase the diversity of people and approaches in mathematical and physical sciences.

To help the programs in MPS meet these goals, the Directorate encourages collaboration with other NSF directorates and with other agencies and industrial organizations. MPS also encourages communication among the divisions and across directorate boundaries to ensure effective support of research and education projects in emerging fields that cut across those lines.

MPS is an active participant in a number of interagency and intra-agency programs that focus on interdisciplinary areas of importance to the national interest. These programs include advanced materials and processing; biotechnology; environment and global change; high-performance computing and communications; advanced manufacturing technologies; civil infrastructure systems; and science, mathematics, engineering, and technology education. Researchers and educators interested in exploring opportunities in these areas should contact the program most closely related to their own interests to learn more about submitting proposals.

The MPS Directorate supports programs and activities through the following:

- **Office of Multidisciplinary Activities (OMA)**
- **Division of Astronomical Sciences (AST)**
- **Division of Mathematical Sciences (DMS)**
- **Division of Physics (PHY)**
- **Division of Chemistry (CHE)**
- **Division of Materials Research (DMR)**

## ⓘ For More Information

Visit the MPS Directorate home page, http://www.nsf.gov/home/mps/.

# OFFICE OF MULTIDISCIPLINARY ACTIVITIES

In 1995, the Office of Multidisciplinary Activities (OMA) was established in the Directorate for Mathematical and Physical Sciences and charged with facilitating and supporting opportunities that cross traditional disciplinary boundaries. OMA works in partnership with the five MPS Divisions—Astronomical Sciences, Chemistry, Materials Research, Mathematical Sciences, and Physics—to respond more effectively to the excellence and creativity of the MPS communities, particularly to proposals that, because of their subject, scope, or multi-investigator or multidisciplinary nature, did not readily fit the existing MPS program structure.

OMA provides a focal point in the Directorate for partnerships (e.g., with other agencies, industry, national laboratories, State and local governments, international organizations), seeds crosscutting research in areas of particular promise, and supports innovative experiments in education that could lead to new paradigms in graduate and undergraduate education in the mathematical and physical sciences, particularly in multidisciplinary settings.

OMA is open to creative ideas from all segments of the MPS community, ranging from individual investigators to centers. It especially encourages initiatives by multi-investigator, multidisciplinary teams pursuing problems on a scale that exceeds the capacity of individual investigators. OMA is particularly receptive to projects incorporating education and research training experiences that contribute to a diverse, high-quality workforce with technical and professional skills, career path flexibility, and appetite for lifelong learning appropriate to the dynamic, global science, and technology enterprise of the 21st century.

In addition to encouraging creative proposals from the community, OMA works with MPS Divisions to identify areas of research and education that are seen as particularly timely and promising. Three areas of emphasis for fiscal year 2002 are the development of next-generation instrumentation to enable fundamental advances within disciplines and across disciplinary boundaries; innovations in education, particularly at the graduate and undergraduate levels, that broaden the backgrounds and strengthen the technical, professional, and personal skills of graduates; and research at the interface between MPS disciplines and the biological sciences where there are extraordinary opportunities for mathematical and physical scientists to use their expertise in addressing significant research and instrumentation challenges in the biosciences and biomedical-related sciences.

In partnership with the MPS Divisions, OMA coordinates three MPS-wide activities that integrate research and education:

**1. Research Experiences for Teachers (RET)—**Utilizes the extensive network of Research Experiences for Undergraduates (REU) Sites as a platform for providing in-service and preservice K–12 teachers with discovery-based learning experiences in the MPS disciplines that they can incorporate into their classroom activities.

**2. MPS Distinguished International Postdoctoral Research Fellowships (MPS-DRF)—**Enable postdoctoral investigators in MPS disciplines to carry out research at the world's leading facilities and laboratories. A primary objective of the

MPS-DRF activity is to provide talented, recent doctoral recipients in the mathematical and physical sciences with an effective means of establishing international collaborations in the early stages of their careers, thereby facilitating and enhancing connections between the U.S. science and engineering community and its international counterparts (see program announcement NSF 00-142).

**3. MPS Internships in Public Science Education (MPS-IPSE)—**Are intended to bring together the expertise of the scientific research community traditionally supported by the MPS Directorate with that of the public science education community, in partnership, to communicate the most recent scientific advances to the public. The IPSE activity provides support for undergraduate and graduate students and for K–12 teachers to work in conjunction with MPS research scientists and with professionals at science centers and museums on projects in public science education (see program announcement NSF 01-39).

### ⓘ For More Information

Write to the Head, Office of Multidisciplinary Activities, Directorate for Mathematical and Physical Sciences, 4201 Wilson Boulevard, Room 1005, Arlington, VA 22230; or contact the office by telephone, 703-292-8803.

# DIVISION OF ASTRONOMICAL SCIENCES

The NSF is the lead Federal agency for the support of ground-based astronomy. Funding is provided through grants, contracts, and cooperative agreements awarded in response to unsolicited, investigator-initiated proposals.

Program areas in the Division of Astronomical Sciences (AST), supported primarily through individual investigator awards, include planetary astronomy, stellar astronomy and astrophysics, galactic astronomy, extragalactic astronomy, and cosmology. A broad base of observational, theoretical, and laboratory research is aimed at understanding the states of matter and physical processes in the solar system, our Milky Way galaxy, and the universe. Funding is also available for advanced technologies and instrumentation, university radio facilities, and a variety of special programs.

AST supports the development and operation of four National Astronomy Centers: National Optical Astronomy Observatory (NOAO), National Solar Observatory (NSO), National Radio Astronomy Observatory (NRAO), and National Astronomy and Ionosphere Center (NAIC). AST also provides the U.S. share of funding for the operation of the Gemini Observatory, an international partnership that has two 8-meter optical/infrared telescopes. The astronomy centers are equipped with radio, optical, infrared, and special telescopes that are made available to the scientific community on a competitive basis. Staff at the centers give technical assistance to visiting scientists, conduct research of their own, and develop advanced instrumentation. The Electromagnetic Spectrum Management Unit is responsible for ensuring that the scientific community has access to the radio spectrum for research purposes.

AST support for astronomy and astrophysics research is provided through two categories:

- **Research Projects and Instrumentation**
- **Facilities**

## ⓘ For More Information

Write to the Division of Astronomical Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 1045, Arlington, VA 22230; or contact the division by telephone, 703-292-8820; or visit the AST home page, http://www.nsf.gov/mps/divisions/ast. Further information about deadlines for proposal submission is available at http://www.nsf.gov/mps/divisions/ast/news/c_deadlines.htm.

## RESEARCH PROJECTS AND INSTRUMENTATION

This category consists of the following astronomy and astrophysics grant programs:

1. **Extragalactic Astronomy and Cosmology**
2. **Galactic Astronomy**
3. **Planetary Astronomy**
4. **Stellar Astronomy and Astrophysics**
5. **Education, Human Resources, and Special Programs**
6. **Electromagnetic Spectrum Management**
7. **Advanced Technologies and Instrumentation**
8. **University Radio Observatories**

**1. Extragalactic Astronomy and Cosmology (EXC)—**Theoretical and observational studies of extragalactic objects—ranging from nearby galaxies to the most distant quasars—and their relevance to galactic evolution and cosmology.

**2. Galactic Astronomy (GAL)—** Theoretical and observational studies on the structure and evolution of the Milky Way galaxy and nearby galaxies. Research may focus on the stellar populations in these galaxies; the characteristics of star clusters; the interstellar medium; and the properties of atoms and molecular constituents of the interstellar medium.

**3. Planetary Astronomy (PLA)—** Theoretical and observational studies of the detailed structure and composition of planetary surfaces, interiors, atmospheres, and satellites; the nature of small bodies (asteroids and comets); and the origin and development of the solar system.

**4. Stellar Astronomy and Astrophysics (SAA)—**Theoretical and observational studies of the structure and activity of the Sun and other stars; the physical properties of all types of stars; all aspects of star formation and stellar evolution; stellar nucleosynthesis; and the properties of atoms and molecules of relevance to stellar astronomy.

**5. Education, Human Resources, and Special Programs—**Coordinates research support in special areas and educational and outreach programs that are related to astronomy. Programs include Research Experiences for Undergraduates (REU) Sites and Supplements, Faculty Early Career Development (CAREER), Presidential Early Career Awards for Scientists and Engineers (PECASE), Research at Undergraduate Institutions (RUI), Research Opportunity Awards (ROA), NSF Astronomy and Astrophysics Postdoctoral Fellowships (AAPF), and programs for underrepresented minorities. Additional information on NSF-wide programs can be found on the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm.

**6. Electromagnetic Spectrum Management—**Ensures the access of the scientific community to portions of the radio spectrum that are needed for research purposes. With other government agencies, coordinates the use of the radio spectrum for research purposes and obtains spectrum support for NSF radio communication systems, when required.

**7. Advanced Technologies and Instrumentation—**Supports the development and construction of state-of-the-art detectors and instruments for the visible, infrared, and radio regions of the spectrum; interferometric imaging instrumentation; adaptive optics; and the application of new hardware and software technology and innovative techniques in astronomical research. Proposals should clearly identify the astronomical measurement objectives that will be enabled and include a brief task implementation plan with milestones, schedules, and costs.

**8. University Radio Observatories—** Supports university-based observatories as centers for focused and innovative scientific and technical achievement, emphasizing the training of young radio astronomers. Fosters hands-on involvement of students in instrument building and telescope operations to help maintain the future health of U.S. radio astronomy.

## FACILITIES

This section supports astronomical facilities and instrumentation that are available on a competitive basis to qualified scientists from all over the world. Telescope time is assigned after judgment of research proposals on the basis of scientific merit, the capability of the instruments to do the work, and the availability of the telescope during the requested time. The Astronomical Sciences Division supports the following facilities:

1. **Gemini Observatory**
2. **National Astronomy and Ionosphere Center**
3. **National Optical Astronomy Observatory**
4. **--Kitt Peak National Observatory**
5. **--Cerro Tololo Inter-American Observaotyr**
6. **National Radio Astronomy Observatory**
7. **National Solar Observatory**

**1. Gemini Observatory—**An international partnership involving the United States, the United Kingdom, Canada, Australia, Chile, Brazil, and Argentina. The project involves the construction and operation of two 8-meter telescopes: one in the Northern Hemisphere on Mauna Kea, HI, and one in the Southern Hemisphere on Cerro Pachon, Chile. The twin telescopes are infrared-optimized, have superb image quality, and provide unprecedented optical and infrared coverage of the northern and southern skies for astronomical research. Scientific operations began on Gemini North in 2000 and on Gemini South in summer 2001.

These telescopes provide astronomers from the partnership countries with world-class observing facilities. Observing time is assigned on the basis of scientific merit. NSF acts as the executive agency for the partnership, and the Association of Universities for Research in Astronomy, Inc.—a consortium of 20 major universities—smanages the Gemini Observatory.

**For More Information**

Visit the Gemini Observatory home page, http://www.gemini.edu/.

**2. National Astronomy and Ionosphere Center (NAIC)—**A visitor-oriented national research center, supported by NSF and focusing on radio and radar astronomy and atmospheric sciences. NAIC's headquarters in Ithaca, NY, are operated and managed for NSF by Cornell University. Its principal observing facilities are 19 kilometers south of the city of Arecibo, Puerto Rico. NAIC provides telescope users with a wide range of instrumentation for research and observation. The center has a permanent staff of scientists, engineers, and technicians who are available to help visiting investigators with their observation programs.

NAIC's principal astronomical research instrument is a 305-meter fixed spherical radio/radar telescope, the world's largest single radio wavelength reflector. Its frequency capabilities range from 25 megahertz to 10 gigahertz. Transmitters include an S-band (2,380-megahertz) radar system for planetary studies and a 430-megahertz radar system for aeronomy studies.

**ⓘ For More Information**

Write to the Director, National Astronomy and Ionosphere Center, Cornell University, Ithaca, NY 14853; or visit the NAIC home page, http://aosun.naic.edu/.

**3. National Optical Astronomy Observatory (NOAO)—**A national center for research in ground-based optical and infrared astronomy, supported by NSF. It has large optical telescopes, observing instrumentation, and data analysis equipment, and the NOAO staff of astronomers, engineers, and various support personnel are available to assist qualified visiting scientists in their use of the facilities.

NOAO, whose headquarters are in Tucson, AZ, is operated and managed by the Association of Universities for Research in Astronomy, Inc. (AURA). NOAO is composed of the following observatories:

- **Kitt Peak National Observatory (KPNO)—**The observing facilities of KPNO are on Kitt Peak, a 2,089-meter mountain 90 kilometers southwest of Tucson, AZ. KPNO includes the 3.5-meter WIYN telescope, the 4-meter Mayall telescope, and a 2.1-meter general-purpose reflector. Numerous other telescopes operated by universities or private consortia are also tenants on Kitt Peak. A full complement of state-of-the-art spectroscopic and imaging instrumentation is available for use on these telescopes.

- **Cerro Tololo Inter-American Observatory (CTIO)—**Qualified scientists are provided with telescopes and related facilities for astronomical research in the Southern Hemisphere. CTIO has offices, laboratories, and living quarters in the coastal city of La Serena, Chile, 482 kilometers north of Santiago. The observing facilities are on Cerro Tololo, a 2,194-meter mountain on the western slopes of the Andes, 64 kilometers inland from La Serena.

CTIO operates the 4-meter Blanco telescope, which is a near twin to the 4-meter Mayall at Kitt Peak, and a general-purpose 1.5-meter reflector. These telescopes are equipped with instruments similar to those at KPNO. Several other telescopes operated by U.S. universities are also located on Cerro Tololo. A new technology 4-meter telescope (Southern Observatory for Astrophysical Research–SOAR) is under construction on nearby Cerro Pachon.

- The **U.S. Gemini Program (USGP)** at NOAO serves as the gateway to the International Gemini Observatory for the

U.S. astronomical community and represents the U.S. scientific, technical, and instrumentation interests in the international community of the Gemini Project.

### ⓘ For More Information

Write to the Director, National Optical Astronomy Observatories, P.O. Box 26732, Tucson, AZ 85726; or visit the NOAO home page, http://www.noao.edu/noao.html.

**4. National Radio Astronomy Observatory (NRAO)—**Offers the use of radio astronomy facilities to qualified scientists. The staff at NRAO help visiting scientists use the large radio antennas, receivers, and other equipment needed to detect, measure, and identify radio waves from astronomical objects.

NRAO headquarters are in Charlottesville, VA. Observing sites are in Green Bank, WV; a site 80 kilometers west of Socorro, NM; and 10 other sites in the continental United States and on the islands of Hawaii and St. Croix, U.S. Virgin Islands. The St. Croix site includes individual antennas of the Very-Long-Baseline Array (VLBA). NRAO is supported under the terms of a cooperative agreement between NSF and Associated Universities, Inc. (AUI), the organization responsible for the operation and management of the observatory.

The new 100-meter Robert C. Byrd Green Bank Telescope, dedicated in August 2000, is now being commissioned and has begun limited scientific use. The Very Large Array (VLA) telescope, located west of Socorro, New Mexico, consists of 27 antennas and carries out aperture synthesis observations of faint radio sources at high angular resolution. The VLBA is a transcontinental network of 10 25-meter antennas that operate at frequencies ranging from 330 MHz to 43 GHz. It carries out ultra-high-resolution studies of extragalactic and galactic sources and allows users to observe both continuum and spectral line emission.

### ⓘ For More Information

Write to the Director, National Radio Astronomy Observatory, Edgemont Road, Charlottesville, VA 22903; or visit the NRAO home page, http://www.nrao.edu.

**5. National Solar Observatory (NSO)—**Makes available to qualified scientists the world's largest collection of optical and infrared solar telescopes and auxiliary instrumentation for observation of the solar photosphere, chromosphere, and corona.

NSO has observing facilities atop Kitt Peak, AZ, and Sacramento Peak, NM (NSO/SP). Kitt Peak telescopes include the 1.5-meter McMath-Pierce Solar Telescope (the world's largest solar research instrument) and a solar vacuum telescope/magnetograph. The McMath complex is designed primarily for solar observations but is also used for planetary and stellar observations and for laboratory high-resolution spectroscopy. The principal instrument of NSO/SP is the 0.76-meter Dunn Solar Telescope, the vacuum tower telescope, equipped with adaptive optics to produce the world’s best spatial resolution for solar studies. Also available are spectrographs and the Advanced Stokes Polarimeter. The Evans Solar Facility is a 40-centimeter aperture coronagraph with spectrographs and a coronal photometer. The NSO also operates the Global Oscillation Network Group (GONG)—a worldwide network of six solar telescopes for helioseismology—and the GONG Data Center in Tucson, AZ. NSO is leading the design effort for a new 4-meter Advanced Technology Solar Telescope (ATST).

### ⓘ For More Information

Visit the NSO home page, http://www.nso.noao.edu/welcome.html; or write to the Director, National Solar Observatory, Box 62, Sunspot, NM 88349.

# DIVISION OF MATHEMATICAL SCIENCES

The Division of Mathematical Sciences (DMS) supports a wide range of projects aimed at developing and exploring the properties and applications of mathematical structures. Most of these projects are those awarded to single investigators or small groups of investigators working with graduate students and postdoctoral researchers. Programs such as Mathematical Sciences Infrastructure handle activities that fall outside this mode.

DMS programs and activities are organized within the following:

- **Disciplinary Programs**
- **Other Programs of Interest**

**Proposals for General Conferences, Workshops, Symposia, Special Years, and Related Activities in DMS**

Proposals for general conferences, workshops, symposia, special years, and related activities should be submitted to the appropriate disciplinary program. Proposals should be submitted 1 year before the start of the activity. Contact the division for information on proposal requirements or see program solicitation NSF 00-109.

**Specific Types of Grants Supported by DMS**

In addition to the usual types of research grants awarded to principal investigators and institutions, DMS supports the following:

- **University/Industry Cooperative Research—**DMS feels it is important to provide more opportunities to conduct research and training in an industrial environment and for industrial scientists to return periodically to academia. To facilitate both research and training, the division provides Mathematical Sciences University/Industry Postdoctoral Research Fellowships, Senior Research Fellowships, and Industry-Based Graduate Research Assistantships and Cooperative Fellowships in the Mathematical Sciences.

- **Interdisciplinary Grants—**Enable faculty members to expand their skills and knowledge into areas beyond their disciplinary expertise, to subsequently apply that knowledge to their research, and to enrich the educational experiences and career options for students. These grants support interdisciplinary experiences at the principal investigator's (PI's) institution (outside the PI's department) or at academic, financial, or industrial institutions in a nonmathematical science environment.

### ⓘ For More Information

Write to the Division of Mathematical Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 1025, Arlington, VA 22230; or contact the division by telephone, 703-292-8870; or visit the DMS home page, http://www.nsf.gov/mps/divisions/dms.

## DISCIPLINARY PROGRAMS

The Division of Mathematical Sciences supports the following disciplinary programs:

1. **Algebra, Number Theory, and Combinatorics**
2. **Analysis**
3. **Applied Mathematics**
4. **Computational Mathematics**
5. **Geometric Analysis**
6. **Statistics and Probability**
7. **Topology and Foundations**

### ⓘ For More Information

Write to the Division of Mathematical Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 1025, Arlington, VA 22230; or contact the division by telephone, 703-292-8870; or visit the DMS home page, http://www.nsf.gov/mps/divisions/dms.

**1. Algebra, Number Theory, and Combinatorics—**Supports research in algebra, including algebraic structures; general algebra and linear algebra; number theory, including algebraic and analytic number theory; algebraic geometry; quadratic forms and automorphic forms; and combinatorics and graph theory.

**2. Analysis—**Supports research on properties and behavior of solutions of differential equations; variational methods; approximations and special functions; analysis in several complex variables and singular integrals; harmonic analysis and wavelet theory; Kleinian groups and theory of functions of one complex variable; real analysis; Banach spaces, Banach algebras, and function algebras; Lie groups and their representations; harmonic analysis; ergodic theory and dynamical systems; some aspects of mathematical physics such as Schroedinger operators and quantum field theory; and operators and algebras of operators on Hilbert space.

**3. Applied Mathematics—**Supports research in any area of mathematics except probability or statistics. Research is expected to be motivated by or have an effect on problems arising in science and engineering, although intrinsic mathematical merit is the most important factor. Areas of interest include partial differential equations that model natural phenomena or that arise from problems in science and engineering, continuum mechanics, reaction-diffusion and wave propagation, dynamical systems, asymptotic methods, numerical analysis, variational methods, control theory, optimization theory, inverse problems, mathematics of biological or geological sciences, and mathematical physics.

**4. Computational Mathematics—**Supports research in algorithms, numerical and symbolic methods, and research in all areas of the mathematical sciences in which computation plays a central and essential role. The prominence of computation in the research is a key distinction between Applied and Computational Mathematics.

**5. Geometric Analysis—**Supports research on differential geometry and its relation to partial differential equations and variational principles; aspects of global analysis, including the differential geometry of complex manifolds and geometric Lie group theory; geometric methods in modern mathematical physics; and geometry of convex sets, integral geometry, and related geometric topics.

**6. Statistics and Probability—**Supports research on statistical theory and methods, which are used to plan scientific experiments and to understand and analyze

data. Major subfields include parametric and nonparametric inference, sequential analysis, multivariate analysis, Bayesian analysis, experimental design, time series analysis, resampling methods, and robust statistics. Almost all of these subfields are computationally intensive. Probability theory is the study of mathematical structures that provide tractable models to statistics and many diverse areas, such as physics, chemistry, biology, biosciences, geosciences, and engineering. Major subfields include stochastic processes, limit theory, infinite particle systems, stochastic analysis in Banach spaces, martingales, and Markov processes.

**7. Topology and Foundations—**Supports research on algebraic topology, including homotopy theory, ordinary and extraordinary homology and cohomology, cobordism theory, and K-theory; topological manifolds and cell complexes, fiberings, knots, and links; differential topology and actions of groups of transformations; general topology and continua theory; and mathematical logic, including proof theory, recursion theory and model theory, foundations of set theory, and infinitary combinatorics.

## OTHER PROGRAMS OF INTEREST

In addition to support in the disciplinary programs, the Division of Mathematical Sciences (DMS) offers activities that differ from the usual type of research projects. A few examples of these programs are included here. For additional programs and further information, visit the DMS home page, http://www.nsf.gov/mps/divisions/dms.

1. **Mathematical Sciences Research Institutes and Other Activities**
2. **Focused Research Groups**
3. **Grants for Vertical Integration of Research and Education**
4. **Cross-Disciplinary Interaction**

### For More Information

Write to the Division of Mathematical Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 1025, Arlington, VA 22230; or contact the division by telephone, 703-292-8870; or visit the DMS home page, http://www.nsf.gov/mps/divisions/dms.

### 1. Mathematical Sciences Research Institutes and Other Activities

- **Mathematical Sciences Research Institutes—**DMS currently funds three Mathematical Sciences Research Institutes. These institutes stimulate research in the mathematical sciences through thematic programs and workshops and advance the training of junior researchers in specialties related to those activities through postdoctoral fellowships of 1- to 2-years. The existing sites meet only part of the Nation's need for support of communication and for collaborative work on mathematical and statistical problems. In fiscal year 2002, DMS anticipates the establishment of new institutes that will advance research in the mathematical sciences and/or the interface of the mathematical sciences and other disciplines; address the diverse challenges and opportunities facing the Nation to which the mathematical sciences can contribute; and promote the integration of research and education.

- **Regional Conferences—**Operated by the Conference Board of the Mathematical Sciences, these conferences feature a principal speaker who gives 10 one-hour talks on a particular subject during a weeklong session.

- **Scientific Computing Research Environments in the Mathematical Sciences—**Offers moderate grants for computing equipment that will benefit groups of outstanding researchers who are highly productive but whose work has been seriously impeded by the lack of computing facilities.

- **Undergraduate Activities—**Awards are made in conjunction with NSF-wide undergraduate efforts, including Research Experiences for Undergraduates (REU), cooperative activities with the Directorate for Education and Human Resources (EHR), and other related activities. For more information on REU, visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm. Further information about EHR programs and activities can be found in the EHR section in this Guide.

- **Mathematical Sciences Postdoctoral Research Fellowships—** Fellowships will be awarded to between 25 and 30 new fellows in 2002. Tenure provides a research instructorship option.

**Eligibility Requirements for the Mathematical Sciences Postdoctoral Research Fellowships**

Each applicant will be required to submit a research plan for the tenure period requested. The fellowships are not intended to support the preparation of prior research results for publication or the writing of textbooks.

To be eligible for one of these fellowships, an individual must (1) be a citizen, national, or lawfully admitted permanent resident alien of the United States as of January 1, 2002; (2) have earned by the beginning of his or her fellowship tenure a doctoral degree in one of the mathematical sciences listed above, or have research training and experience equivalent to that represented by a Ph.D. in one of those fields; and (3) have held the doctorate for no more than 2 years, as of January 1, 2002.

**2. Focused Research Groups—**The mathematical sciences thrive on sharing of ideas from various fields and disciplines, and certain research needs can be met appropriately only by teams of investigators. The Division of Mathematical Sciences supports such teams through the Focused Research Groups (FRG) Program. The FRG Program allows groups of researchers to respond to scientific needs of pressing importance; to take advantage of current scientific opportunities; or to prepare the ground for anticipated developments in the mathematical sciences. In addition to mathematical scientists, groups may include researchers from other scientific and engineering disciplines. FRG projects are highly focused scientifically, timely, limited to 3 years' duration, and substantial in both scope and impact. Projects supported through FRG are essentially collaborative in nature, their success dependent on the interaction of a group of researchers.

**3. Grants for Vertical Integration of Research and Education—**DMS seeks to assist universities in preparing undergraduate students, graduate students, and postdoctoral fellows for a broad range of opportunities in the mathematical sciences, and to encourage departments in the mathematical sciences to consider a spectrum of educational activities and their integration with research. Through the Grants for Vertical Integration of Research and Education (VIGRE) Program, DMS supports efforts by institutions with Ph.D.-granting departments in the mathematical sciences to carry out innovative educational programs, at all levels, that are integrated with the department's research activities. Proposals should have a core, coherent plan for integration of an undergraduate research experience; a graduate traineeship

program; a postdoctoral fellowship program; and undergraduate and graduate curriculum reviews.

**4. Cross-Disciplinary Interaction—**A number of areas in science and engineering have problems of great mathematical and statistical complexity or obscurity that are creating a demand for mathematical and statistical cooperation. The depth of the problems being raised often exceeds that of the training of the scientists and engineers currently in mathematical and statistical theory. To progress in solving these problems, mathematical scientists must be sought to work in tandem with other scientists. At the same time, the problems posed often stimulate interesting, new, and deep mathematical and statistical questions that deserve attention. DMS hopes to foster interactions that require the participants to go well beyond their respective areas of expertise, to nurture young talent in the interdisciplinary mode of research, and to involve underrepresented groups whenever possible.

The following are some of the exciting research opportunities:

- In the area of biosciences and biocomplexity, striking advances in biology, computer science, and the mathematical sciences are creating opportunities to collaborate on research work in fields such as molecular biology, neuroscience, and ecosystems, and offer challenging computational and analytical problems. Biological sciences interaction may extend significantly into the core areas of mathematics, such as topology, operator algebra, probability, and nonlinear dynamical systems, as well as the more traditional areas of applied mathematics and statistics.

- Other opportunities include research in the areas of high-performance computing and communications; research in information technology; mathematical and statistical aspects of materials behavior and theoretical continuum mechanics; geosciences; advanced manufacturing technologies; mathematical sciences related to biotechnology; and mathematical, statistical, and computational aspects of global change research. Research in the area of materials includes interaction of thermal and mechanical effects; nanoscale science, phase transition, and formation of microstructures and crystals; foundations of nonlinear elasticity and electromagnetic materials; composite materials; and related mathematical questions such as control, optimization, and studies of differential equations arising in these contexts. Research opportunities in advanced manufacturing particularly emphasize simulation, modeling, and analysis of manufacturing processes and devices; applications for manufacturing of deterministic and stochastic quality control; and optimization. Mathematical science research related to biocomplexity, bioprocessing and bioconversion, bioelectronics and bionetworks, agricultural applications, and marine biotechnology is especially encouraged.

Environmental research supports the critical development of modeling, analysis, simulation, and prediction in the context of the total Earth system. A particular emphasis is placed on analytical and computational methods for stochastic and deterministic partial differential equations and statistical techniques that encompass the full range of temporal and spatial scales. There also are opportunities in environmental technology, including pollution prevention, monitoring, and remediation. Researchers should be aware of the implications of their efforts toward such activities.

# DIVISION OF PHYSICS

The Division of Physics (PHY) supports a wide range of activities in the different subfields of physics. The primary mode of funding is to individual investigators or small groups. The division also funds the operation of two large-scale accelerator facilities (the Cornell Electron Storage Ring and the Michigan State University National Superconducting Cyclotron Laboratory); the Laser Interferometer Gravity Wave Observatory; several smaller-scale accelerators; a number of centers in atomic, molecular, and optical physics and in theoretical physics; and a new program of Physics Frontiers Centers.

The research activities in the Physics Division are inextricably linked to education and support about 800 graduate students who are fully engaged in research. Some of these activities involve substantial numbers of undergraduate students as well, especially the summer activities that are centered around the Research Experiences for Undergraduates (REU) Program. The division now supports approximately 50 REU Sites. Research activities at 4-year colleges are supported through the Research at Undergraduate Institutions (RUI) Program. The division also supports Research Experiences for Teachers through grants to provide grade K–12 science teachers with research training opportunities. In addition, the division offers significant training opportunities for young people through its support of about 500 postdoctoral positions. The division also supports outreach activities coupled to research that are intended to convey the excitement of physics to students in grades K–12 and to help educate the public at large in forefront science.

PHY supports the following programs and activities:

1. **Atomic, Molecular, Optical, and Plasma Physics**
2. **Elementary Particle Physics**
3. **Gravitational Physics**
4. **Nuclear Physics**
5. **Particle and Nuclear Astrophysics**
6. **Theoretical Physics**
7. **Education and Interdisciplinary Research**
8. **Physics Frontiers Centers**

### ⓘ For More Information

Write to the Division of Physics, National Science Foundation, 4201 Wilson Boulevard, Room 1015, Arlington, VA 22230; or contact the division by telephone, 703-292-8890; or visit the PHY home page, http://www.nsf.gov/mps/divisions/phy.

**1. Atomic, Molecular, Optical, and Plasma Physics—**In Atomic and Molecular Physics, research is supported in areas such as quantum control, cooling and trapping of atoms and ions, low-temperature collision dynamics, the collective behavior of atoms in weakly interacting gases (Bose-Einstein Condensates), precision measurements of fundamental constants, and the effects of electron correlation on structure and dynamics. In Optical Physics, support is provided in areas such as nonlinear response of isolated atoms to intense, ultrashort electromagnetic fields; the atom/cavity interaction at high fields; and quantum properties of the electromagnetic field. In basic Plasma Physics, support focuses on the study of the behavior of plasmas in confined magnetic structures and in laser plasma interactions.

Several centers and one user facility are supported. The Joint Institute for Laboratory Astrophysics (JILA) at the University of Colorado is supported jointly with the

National Institute of Standards and Technology. JILA conducts leading-edge research in many aspects of atomic, molecular, and optical physics. The Center for Ultrafast Optical Science at the University of Michigan develops new ultrafast laser tools and applies them in the study of coherent control, high-field laser/matter interactions, and biological and medical problems. The Center for Ultracold Atoms, a joint MIT-Harvard University activity, conducts research in the area of Bose-Einstein condensates and coherent atom sources. The Large Aperture Plasma Device at UCLA is supported jointly with the Department of Energy as a user facility for the study of plasma waves.

**2. Elementary Particle Physics—** Supports research on the properties and interactions of elementary particles, the most fundamental building blocks of matter, at the frontiers of energy and sensitivity. Research includes the exploration of quarks and leptons and the interactions among these elementary constituents. The program supports university groups working at major accelerator laboratories, including those operated by the Department of Energy, and university groups involved in the construction of detectors for the Large Hadron Collider at the European Organization for Nuclear Research (CERN).

The program supports the Cornell Electron Storage Ring (CESR), which produces electron and positron colliding beams that allow detailed studies by university groups of b-meson physics and upsilon physics, and facilitates an aggressive program of synchrotron radiation research at the Cornell High-Energy Synchrotron Source, which is operated by the Division of Materials Research. CESR is among the highest luminosity electron-positron colliders in the world in this energy range. CESR also maintains a vigorous program of accelerator research and development.

**3. Gravitational Physics—**Emphasizes the theory of strong gravitational fields and their application to astrophysics and cosmology, computer simulations of strong and gravitational fields, and gravitational radiation; and construction of a quantum theory of gravity. The program oversees the management of the construction, commissioning, and operation of the Laser Interferometer Gravity Wave Observatory (LIGO), and provides support for LIGO users and other experimental investigations in gravitational physics and related areas.

**4. Nuclear Physics—**Supports research on properties and behavior of nuclei and nuclear matter under extreme conditions; the quark-gluon basis for the structure and dynamics of nuclear matter (which is now given in terms of mesons and nucleons); phase transitions of nuclear matter from normal nuclear density and temperature to the predicted high-temperature quark-gluon plasma; and basic interactions and fundamental symmetries. This research involves many probes, including intermediate-energy to multi-GeV electrons and photons; intermediate-energy light ions; low-energy to relativistic heavy ions, including radioactive beams; and non-accelerator-based studies. Other important components of the program include accelerator physics, interdisciplinary efforts, and applications to other fields.

The program supports university user groups executing experiments at a large number of laboratories in the United States and abroad, and a national user facility--the National Superconducting Cyclotron Laboratory, a superconducting, heavy-ion cyclotron facility at Michigan State University. The program also supports smaller accelerator facilities, such as those at Florida State University, the University of Notre Dame, and the State University of New York at Stony Brook.

**5. Particle and Nuclear Astrophysics—** Supports university groups conducting research in particle and nuclear astrophysics. Current supported activities are high-energy cosmic ray studies, solar and high-energy neutrino astrophysics, the study of gamma ray bursts, and searches for dark matter. Under construction are the Auger, HiRes, STACEE, and Milagro cosmic ray/gamma ray detectors, the Borexino solar neutrino detector, the Amanda II high-energy neutrino detector, and the CDMS II and DRIFT dark matter detectors. Support also is provided for accelerator-based nuclear astrophysics studies of stellar process, nucleosynthesis, and processes related to cosmology and the early universe.

**6. Theoretical Physics—**Supports the development of qualitative and quantitative understanding of fundamental physical systems, ranging from the most elementary constituents of matter through nuclei and atoms to astrophysical objects. This includes formulating new approaches for theoretical, computational, and experimental research that explore the fundamental laws of physics and the behavior of physical systems; formulating quantitative hypotheses; exploring and analyzing the implications of such hypotheses computationally; and, in some cases, interpreting the results of experiments. Support is given for research in the following areas: elementary particle physics; nuclear physics; atomic, molecular, optical, and plasma physics; astrophysics and cosmology; and a broad spectrum of topics in mathematical physics, computational physics, nonlinear dynamics, chaos, and statistical physics. The effort also includes a considerable number of interdisciplinary grants.

In addition, the program supports infrastructure activities such as the Institute for Theoretical Physics at the University of California at Santa Barbara, the Harvard-Smithsonian Institute for Theoretical Atomic, Molecular, and Optical Physics, and the Aspen Center for Physics. These activities include both short- and long-term visitor programs, workshops, and research involving the participation of external scientists from universities, national laboratories, and industry, as well as graduate students and postdoctoral fellows.

**7. Education and Interdisciplinary Research—**Supports activities in conjunction with NSF-wide programs such as Faculty Early Career Development (CAREER), Research Experiences for Undergraduates (REU), and programs aimed at women, minorities, and persons with disabilities. Further information about all of these programs and activities is available in the Crosscutting Investment Strategies section in this Guide.

The program also supports activities that seek to improve the education and training of physics students (both undergraduate and graduate), such as curriculum development for upper-level physics courses, and activities that are not included in specific programs elsewhere within NSF. The program supports research at the interface between physics and other disciplines, with particular emphasis on biological physics, but including medical physics and computation, and extending to emerging areas. Broadening activities related to research at the interface with other fields, possibly not normally associated with physics, also may be considered.

**8. Physics Frontiers Centers (PFC's)—** Support university-based centers and large groups in cases where this mode of research is required to make transformational advances in the most promising research areas. Proposals will be considered in areas within the purview of the Division of Physics, broadly interpreted—for example, atomic,

molecular, optical, plasma, elementary particle, nuclear, astro-, gravitational, interdisciplinary, and emerging areas of physics. Interdisciplinary physics is taken here to mean research at the interface between physics and other disciplines—for example, biophysics, quantum information science, and mathematical physics. The purpose of the PFC Program is to enable major advances at the intellectual frontiers of physics by providing needed resources not usually available to individual investigators or small groups. PFC's make it possible to address major challenges that require combinations of talents, skills, and/or disciplines; specialized infrastructure; large collaborations; or centers/institutes that catalyze rapid advances on the most promising research topics. For more information, see program solicitation NSF 01-112.

# DIVISION OF CHEMISTRY

The Division of Chemistry (CHE) supports research and the development of research infrastructure in the principal subdisciplines of chemistry. The field of chemistry is very diverse, and NSF support for chemistry research goes beyond the CHE Division. Other NSF divisions supporting chemistry research include Astronomical Sciences, Atmospheric Sciences, Molecular and Cellular Biosciences, Chemical and Transport Systems, Earth Sciences, Advanced Computational Research, Physics, and Materials Research. Similarly, support for the development of infrastructure in chemistry also is provided by appropriate divisions in the Directorates for Education and Human Resources (EHR) and Biosciences (BIO) through the Division of Biological Infrastructure.

Molecular science plays a central role in many areas of science and engineering. Because of this, much of the research supported by the CHE Division will also further the advancement of research in other disciplines, such as biology and chemical engineering, and in various multidisciplinary or interdisciplinary areas, such as environmental science and materials science.

CHE supports the following programs and activities:

1. **Analytical and Surface Chemistry**
2. **Inorganic, Bioinorganic, and Organometallic Chemistry**
3. **Organic Chemical Dynamics**
4. **Organic Synthesis**
5. **Experimental Physical Chemistry**
6. **Theoretical and Computational Chemistry**
7. **Chemistry of Materials**
8. **Office of Special Projects**
9. **Chemistry Research Instrumentation and Facilities**

### ⓘ For More Information

Write to the Division of Chemistry, National Science Foundation, 4201 Wilson Boulevard, Room 1055, Arlington, VA 22230; or contact the division by telephone, 703-292-8840; or visit the CHE home page, http://www.nsf.gov/mps/divisions/che.

**1. Analytical and Surface Chemistry—** Supports fundamental chemical research directed toward the characterization and analysis of all forms of matter. Studies of elemental and molecular composition and of the microstructure of both bulk and surface domains are included. The program supports projects that develop the fundamentals of measurement science, new sensors and new instruments, and innovative approaches to data processing and interpretation.

Investigations designed to probe the chemical structure and reactivity of the interface between different forms of matter also are supported. The program is linked to several other chemistry research programs within NSF, including Solid State Chemistry (Materials Research Division, MPS Directorate); Biochemistry and Biophysics (Molecular and Cellular Biosciences Division, BIO Directorate); and Chemical Reaction Processes and Interfacial, Transport, and Separation Processes (Chemical and Transport Systems Division, ENG Directorate).

**2. Inorganic, Bioinorganic, and Organometallic Chemistry—**Supports research on the synthesis, properties, and reaction mechanisms of molecules composed of metals, metalloids, and nonmetals with elements covering the entire periodic table. Included are fundamental studies that underscore (1) bioinorganic reactions, (2) homogeneous catalysis and organometallic reactions, (3) photochemical and charge transfer processes, and (4) studies aimed at the rational synthesis of new inorganic molecular substances, self-assemblies, and nano-size materials with predictable chemical, physical, and biological properties. Objectives are to provide the basis for understanding (1) the function of metal ions in biological systems, (2) the behavior of new inorganic materials and new industrial catalysts, and (3) the systematic chemistry and behavior of most of the elements and compounds in the environment. The program has links to other programs within NSF that support chemistry research, including Solid State Chemistry and Polymers (Materials Research Division, MPS Directorate); Chemical Reaction Processes (Chemical and Transport Systems Division, ENG Directorate); Biochemistry and Biophysics (Molecular and Cellular Biosciences Division, BIO Directorate); and Geochemistry (Earth Sciences Division, GEO Directorate).

**3. Organic Chemical Dynamics—**Supports research that will advance the knowledge of carbon-based molecules, metallo-organic systems, and organized molecular assemblies. Experimental, computational, and theoretical projects that illuminate chemical structures, reactivity, and properties and that provide organic mechanistic, structural, and kinetic foundations for the understanding of biological processes are all considered. The program has links to other programs within NSF that support chemistry research, including Solid State Chemistry and Polymers (Materials Research Division, MPS Directorate); Chemical Reaction Processes (Chemical and Transport Systems Division, ENG Directorate); Biochemistry and Biophysics (Molecular and Cellular Biosciences Division, BIO Directorate); and Atmospheric Chemistry (Atmospheric Sciences Division, GEO Directorate).

**4. Organic Synthesis—**Supports research on the synthesis of carbon-based molecules, organometallic systems, and organized molecular assemblies. Research includes the development of new reagents and methods for organic synthesis and characterization, and the investigation of natural products and new organic materials. Such research provides the basis for designed syntheses of new materials and natural products important to the chemical and pharmaceutical industries. The research has links to other programs within NSF that support chemistry research, including Biochemistry (Molecular and Cellular Biosciences Division, BIO Directorate) and Polymers (Materials Research Division, MPS Directorate).

**5. Experimental Physical Chemistry—**Supports experimental research directed at understanding the physical properties of chemical systems at a molecular level. Chemical systems include solids, liquids,

interfaces, clusters, and isolated molecules or ions in gas or condensed phases. Chemical properties of interest include solute/solvent interactions in liquids and in clusters; chemical dynamics of bimolecular and unimolecular chemical processes; time-resolved internal energy redistribution; and molecular structure and the shape of the ground and excited electronic-state potential energy surfaces. Experimental methodologies include frequency domain and time domain spectroscopic techniques covering the entire range of the electromagnetic spectrum; time-resolved dynamical studies, including state-selected and mass-selected systems; reactive scattering; and single-molecule studies.

The program has links to other programs within NSF that support chemistry research, including Atomic, Molecular, and Optical Physics (Physics Division, MPS Directorate); Biophysics (Molecular and Cellular Biosciences Division, BIO Directorate); Atmospheric Chemistry (Atmospheric Sciences Division, GEO Directorate); Galactic Astronomy (Astronomical Sciences Division, MPS Directorate); Chemical and Transport Systems (ENG Directorate); and various programs in the Materials Research Division (MPS Directorate).

**6. Theoretical and Computational Chemistry—**Supports theoretical and computational research in areas of electronic structure, statistical mechanics, computer simulations, and chemical dynamics. The program also supports some areas of experimental thermodynamics and condensed phase dynamics of chemical systems that rely heavily on theoretical interpretation of experimental data. Areas of application span the full range of chemical systems, from small molecules to macromolecules; and degrees of aggregation, from clusters to macroscopic systems. The goal of projects supported in this program is to provide a molecular-level interpretation for chemical properties and reactivity. The program has links to other programs within NSF that support chemistry research, including Atomic, Molecular, and Optical Physics (Physics Division, MPS Directorate); Materials Theory (Materials Research Division, MPS Directorate); Biophysics (Molecular and Cellular Biosciences Division, BIO Directorate); and Advanced Computational Research (Advanced Computational Infrastructure and Research Division, CISE Directorate).

**7. Chemistry of Materials—**Supports chemistry aspects of research problems related to the design, synthesis, and characterization of advanced materials. Emphasis is on projects that take a chemistry-based molecular or supramolecular approach to materials synthesis and performance from an experimental, theoretical, and computational perspective. Current research areas include the synthesis of new molecular organic, inorganic, and organometallic precursors to polymeric, ceramic, electronic, photonic, magnetic, and biomolecular materials; chemical reactivity of polymeric, microporous, and other solid substrates; chemistry of thin films and interfaces as applied to materials performance; synthesis of new molecular nanoscopic materials with novel or improved properties; research on catalysts and reactive molecular intermediates for materials synthesis; the molecular basis of materials properties and performance, such as nonlinear optical activity, conductivity, magnetism, and liquid crystalline behavior; molecular switching and electronics; and supramolecular self-assembly. The activity is strongly linked to several programs in the Materials Research Division (MPS Directorate) and in the ENG and BIO Directorates.

**8. Office of Special Projects—**Supports or coordinates the support for most of the infrastructure programs and activities in which the CHE Division is involved. Examples include the Research

Experiences for Undergraduates, Faculty Early Career Development, and Research Sites for Educators in Chemistry, as well as various special-purpose grants in education, outreach, diversity, and graduate training. The office also coordinates the Division's involvement in large-scale projects, such as the Environmental Molecular Science Institutes and the Science and Technology Centers. The office manages the Collaborative Research in Chemistry Program, whose purpose is to enable groups of researchers to respond to recognized scientific needs; take advantage of current scientific opportunities; or prepare the groundwork for anticipated and significant scientific developments in chemistry, broadly defined. Further information on the research centers and groups supported by the CHE Division is available at http://www.nsf.gov/mps/divisions/che/about/c_facilities.htm.

**9. Chemistry Research Instrumentation and Facilities (CRIF)—**Supports the purchase or upgrade of departmental multiuser instrumentation, instrumentation development, and chemistry research facilities. The first of these topics focuses on departmental development and is intended to facilitate research by grantees and potential grantees that are being supported by the CHE Division. Instrumentation development is intended to implement, test, and introduce new concepts for chemical measurement to be used on a wider scale. Chemistry research facilities provide unique, state-of-the-art instrumentation and expertise to users from the chemical sciences community. Only a few facilities are supported at any time. Individuals interested in submitting a facilities proposal must first contact the appropriate staff person in the CHE Division. CRIF interfaces with the following cross-directorate programs and activities: Major Research Instrumentation; Small Business Innovation Research; Small Business Technology Transfer; and instrumentation programs in the Materials Research Division (MPS Directorate), the Division of Undergraduate Education (EHR Directorate), the Office of Cross-Disciplinary Activities (CISE Directorate), and the Division of Biological Infrastructure (BIO Directorate). For a description of the facilities currently supported by the CHE Division, see http://www.nsf.gov/mps/divisions/che/about/c_facilities.htm.

# DIVISION OF MATERIALS RESEARCH

The Division of Materials Research (DMR) supports a wide range of programs that address fundamental phenomena in materials, materials synthesis and processing, structure and composition, properties and performance, and materials education. DMR supports individual investigators, groups, centers, national facilities, and instrumentation. Individual investigator and group proposals do not have to be confined or targeted to a specific program; division staff work to facilitate the co-review and co-funding of highly meritorious proposals across program, division, or directorate boundaries as appropriate.

DMR-supported programs and activities are organized into the following categories:

- **DMR Programs**
- **Other DMR Activities of Interest**

### ⓘ For More Information

For lists of awards and abstracts, target and deadline dates for proposal submission, or further information about DMR programs and activities, visit the DMR home page, http://www.nsf.gov/mps/divisions/dmr; or

contact DMR by telephone, 703-292-8810; or write to the Division of Materials Research, National Science Foundation, 4201 Wilson Boulevard, Room 1065, Arlington, VA 22230.

## DMR PROGRAMS

1. **Metals**
2. **Ceramics**
3. **Electronic Materials**
4. **Materials Theory**
5. **Condensed Matter Physics**
6. **Solid-State Chemistry**
7. **Polymers**
8. **Materials Research Science and Engineering Centers**
9. **Instrumentation for Materials Research**
10. **National Facilities**

### ⓘ For More Information

For lists of awards and their abstracts, target dates and deadlines for proposal submission, or more information about DMR programs and activities, visit the DMR home page, http://www.nsf.gov/mps/divisions/dmr; or contact DMR by telephone, 703-292-8810; or write to the Division of Materials Research, National Science Foundation, 4201 Wilson Boulevard, Room 1065, Arlington, VA 22230.

**1. Metals—**Supports research to increase understanding and predictive capabilities for relating synthesis, processing, alloy chemistry, and microstructure of metals to their physical and structural properties and performance in various applications and environments. Metals research encompasses the broad areas of physical and mechanical metallurgy. Topics supported include phase transformations and equilibria; morphology; solidification; surface modification, structure, and properties; interfaces and grain boundary structure; nanostructures; corrosion and oxidation; defects; deformation and fracture; and welding and joining.

**2. Ceramics—**Supports research investigating the characteristics of ceramic materials as they relate to the complex interplay among processing, development, and manipulation of microstructure, and properties and their ultimate performance in various applications and environments. The materials studied include oxides, carbides, nitrides, and other ceramics, including diamond and carbon-based materials. The microstructures investigated range from crystalline, polycrystalline, and amorphous to composite and nanostructured. Potential uses include, but are not limited to, electronic and electrical, electrochemical, structural, optical/photonic, and biological/medical applications.

**3. Electronic Materials—**Supports research that investigates the fundamental phenomena associated with the synthesis and processing of electronic and photonic materials. The objective is to increase fundamental understanding and develop predictive capabilities for relating synthesis, processing, and microstructure of these materials to their properties and performance in various applications and environments. Topics supported include basic processes and mechanisms associated with nucleation and growth of thin films; nanostructure definition and etching processes; bulk crystal growth; and the interrelationship among experimental conditions, phenomena, and properties.

**4. Materials Theory—**Supports theoretical and complementary computational research in the topical areas represented in DMR programs, including condensed matter physics, polymers, solid-state chemistry, metals, electronic materials, and ceramics. Materials Theory is the primary source of funding at NSF for condensed matter

theory. The program supports fundamental research that advances conceptual, analytical, and computational techniques for materials research. A broad spectrum of research is supported using electronic structure methods, many-body theory, statistical mechanics, and Monte Carlo and molecular dynamics simulations, along with other techniques, many involving advanced scientific computing. Emphasis is on approaches that begin at the smallest appropriate length scale, such as electronic, atomic, molecular, nano-, micro-, and mesoscale, required to yield fundamental insight into material properties, processes, and behavior and to reveal new materials phenomena. Areas of recent interest include strongly correlated electron systems; low-dimensional systems; nonequilibrium phenomena, including pattern formation, microstructural evolution, and fracture; high-temperature superconductivity; nanostructured materials and mesoscale phenomena; quantum coherence and its control; and soft condensed matter, including systems of biological interest.

**5. Condensed Matter Physics—**Supports fundamental, experimental, and combined experiment and theory projects on the physics of solid, liquid, and amorphous systems. Phenomena of interest include phase transitions; localization; electronic, magnetic, and lattice structure; superconductivity; elementary excitations, including electronic, magnetic, plasma, and lattice; transport, magnetic, and optical properties; and nonlinear dynamics. Low-temperature physics is represented by research on quantum fluids and solids as well as two-dimensional electron systems. Soft condensed matter research includes partially ordered fluids, colloid physics, and hybrid media involving biological molecules. Characterization and analysis of new materials by novel methods and research on condensed matter under extreme conditions—such as low temperatures, high pressures, and high magnetic fields—are of interest. Development of new experimental techniques to carry out proposed projects is encouraged.

**6. Solid-State Chemistry—**Supports basic research that includes understanding the atomic and molecular basis for synthesis, structure-composition-property relationships, and the processing of materials. The program is largely multidisciplinary with strong components of chemistry, physics, biology, and materials science. Special attention is given to the creation of new classes of materials exhibiting new phenomena, and discovering specific materials with superior properties. Current research areas include innovative synthetic routes to new materials; characterization of materials displaying new phenomena or superior behavior; the relationships among structure, composition, and properties such as chemisorption, cooperative-assembly, transport, and reactivity; and materials preparation, processing, and optimization by chemical means. The current materials emphasis is on hybrid materials, complex materials, bio-inspired and environmental materials, and advanced materials optimization and processing.

**7. Polymers—**Supports basic research and education on the materials aspects of polymer science that are largely experimental and multidisciplinary, with strong components of chemistry, physics, and materials science. The program addresses synthesis, structure, morphology, processing, characterization, and structure-property relationships of polymers at the molecular level, with particular focus on new materials or materials with superior properties. The polymers studied are principally synthetic, but there is also an interest in biopolymers.

**8. Materials Research Science and Engineering Centers (MRSEC's)—** Supports interdisciplinary materials research and education while addressing fundamental problems in science and engineering that are important to society. MRSEC's require outstanding research quality and intellectual breadth, provide support for research infrastructure and flexibility in responding to new opportunities, and strongly emphasize the integration of research and education. These centers foster active collaboration between universities and other sectors, including industry, and they constitute a national network of university-based centers in materials research. MRSEC's address problems of a scope or complexity requiring the advantages of scale and interdisciplinary interaction provided by a campus-based research center.

### ⓘ For More Information

For more information about the MRSEC's, including links to the research and education activities of each center, visit the program's home page, http://www.mrsec.org.

**9. Instrumentation for Materials Research—**Supports the development and acquisition of state-of-the-art tools to carry out advanced materials research. The program supports (1) major shared instruments essential to investigators conducting research that spans two or more disciplinary areas within DMR, or more than one NSF division, and (2) instrumentation required by one or more investigators conducting research in a single disciplinary area within DMR that has a total cost of approximately $100,000 or more. The program strongly encourages submission of proposals for the development of new instruments that have the potential to solve important materials problems, proposals that will significantly advance measurement capabilities, and proposals that could lead to new discoveries. For more information, see program announcement NSF 01-05.

**10. National Facilities—**Supports the operation of National User Facilities, which are research facilities with specialized instrumentation available to the scientific research community in general and the materials research community in particular. These facilities provide unique research capabilities that can be located at only a few highly specialized laboratories in the Nation. They include facilities and resources for research using high magnetic fields, ultraviolet and x-ray synchrotron radiation, small-angle neutron scattering, and nanofabrication.

### ⓘ For More Information

Please contact the facilities directly at the addresses listed below.

**Center for High-Resolution Neutron Scattering**
National Institute of Standards and Technology
Reactor Radiation Division
Gaithersburg, MD 20899
Telephone: 301-975-6242
Web address: http://rrdjazz.nist.gov/

**Cornell High-Energy Synchrotron Source**
Wilson Laboratory
Cornell University
Ithaca, NY 14853
Telephone: 607-255-7163
Web address: http://www.chess.cornell.edu/

**National High Magnetic Field Laboratory**
(operated by Florida State University, the University of Florida, and Los Alamos National Laboratory)
Florida State University
1800 E. Paul Dirac Drive
Tallahassee, FL 32306-4005
Telephone: 850-644-0311 or 850-644-0850
Web address: http://www.magnet.fsu.edu/

**Synchrotron Radiation Center**
University of Wisconsin at Madison
3731 Schneider Drive
Stoughton, WI 53589-2200
Telephone: 608-877-2000
Web address: http://www.src.wisc.edu/

**National Nanofabrication Users Network**
Web address: http://www.nnun.org

## OTHER DMR ACTIVITIES OF INTEREST

DMR also supports complementary activities that cut across programmatic lines in many cases. These include awards for Research Experiences for Undergraduates Sites and Supplements, Presidential Early Career Awards for Scientists and Engineers, Faculty Early Career Development, Research at Undergraduate Institutions, Research Opportunity Awards, support for underrepresented minorities, international activities, awards in materials education, and awards for faculty groups addressing problems with broader scope than traditional individual investigator grants. In addition, DMR activities are intrinsic to NSF-wide areas of focus such as nanoscale science and engineering. Some of these activities are described briefly in this section. They include

1. **Focused Research Groups**
2. **Research Experiences for Undergraduates and Research Experiences for Teachers**
3. **Materials Research and Education Awards**
4. **Opportunities for International Cooperation in Materials Research**
5. **Grant Opportunities for Academic Liaison with Industry (GOALI)**

### ⓘ For More Information

For more detailed descriptions of these programs, visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm, or the DMR home page at http://www.nsf.gov/mps/divisions/dmr.

**1. Focused Research Groups (FRG's)—** These are materials research projects that generally are smaller than centers (MRSEC's) and address problems that require an interactive approach involving three or more investigators. This is not a new program, and there is no specific announcement or call for FRG proposals. FRG proposals are handled by individual investigator program directors in the Division of Materials Research, and are reviewed and co-reviewed among DMR and other NSF Program staff as appropriate, recognizing the collaborative, interdisciplinary aspects of such proposals. A list of FRG's currently supported by DMR is available on the DMR home page, http://www.nsf.gov/mps/divisions/dmr/research/start.htm.

**2. Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET)—** DMR supports more than 60 REU Sites, as well as REU supplements for undergraduate participation in research awards. Awards are made in conjunction with the NSF-wide REU Program. To foster participation by precollege science teachers in materials research, DMR also supports awards for RET in conjunction with the MPS Office of Multidisciplinary Activities. For more information on REU, visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm. A list of DMR-supported REU Sites is available on the DMR home page, http://www.nsf.gov/mps/divisions/dmr/research/start.htm.

**3. Materials Research and Education Awards—**DMR supports innovative approaches to materials education at the undergraduate and graduate levels. Awards are made annually through open competition. Current awards are listed on the DMR web page, http://www.nsf.gov/mps/divisions/dmr/research/edawards.doc.

**4. Opportunities for International Cooperation in Materials Research—** DMR supports a growing number of activities to enhance international cooperation in materials research. Examples include supplementary support for existing grants, international workshops, and awards for cooperative research projects and related activities. In many cases, these activities are coordinated and co-funded with the Division of International Programs and other NSF units, including the Directorate for Engineering and the MPS Office for Multidisciplinary Activities. Proposals can usually be submitted to the appropriate disciplinary program. In some cases, they are evaluated through a special competition. A specific example is the program for cooperative activities with Europe, in partnership with the European Community, described in more detail in program announcement NSF 01-105.

**5. Grant Opportunities for Academic Liaison with Industry (GOALI)—**DMR supports a wide range of GOALI awards in materials. The GOALI Initiative aims to synergize university-industry partnerships by making funds available to support an eclectic mix of industry-university linkages. Special interest is focused on affording the opportunity for (1) faculty, postdoctoral fellows, and students to conduct research and gain experience with production processes in an industrial setting; (2) industrial scientists and engineers to bring industry's perspective and integrative skills to academe; and (3) interdisciplinary university-industry teams to conduct long-term projects. This initiative targets high-risk/high-gain research with a focus on fundamental topics that would not have been undertaken by industry; new approaches to solving generic problems; development of innovative collaborative industry-university educational programs; and direct transfer of new knowledge between academe and industry. For more information, see http://www.nsf.gov/home/crssprgm/goali/start.htm.

# POLAR PROGRAMS

The Earth's polar regions offer compelling scientific opportunities, but their isolation and extreme climate challenge the pursuit of these opportunities.

The National Science Foundation (NSF) supports Arctic and Antarctic research and education, both to improve understanding of the regions and their relationship with global processes and to seize opportunities presented by the regions as research platforms. Support is provided for investigations in a range of scientific disciplines in the physical, biological, and social sciences. This range and the unique aspects of polar regions provide opportunities to advance discovery while promoting teaching, training, and learning.

In addition to providing individual grants to scientists and educators at U.S. institutions, NSF funds contractor-provided operational support to field and laboratory science in Antarctica, the Southern Ocean, and the Arctic.

Foundation funding for polar research and education comes from the following sources:

- **Antarctic Sciences (Office of Polar Programs)**
- **Arctic Sciences (Office of Polar Programs)**
- ***Educational Activities (Education and Human Resources Directorate)**
- **Crosscutting Programs (Foundation-wide)**

**Note: Although these areas of NSF do not generally offer polar-specific programs, they can consider and support polar proposals.*

## ⓘ For More Information

Visit the Office of Polar Programs (OPP) home page, http://www.nsf.gov/od/opp/; or visit the OPP Advisory Committee web page to read about ongoing issues regarding OPP and the NSF merit review criterion 2 (broader impacts), http://www.nsf.gov/od/opp/opp_advisory/oaccrit2.htm; or the NSF home page, http://www.nsf.gov/.

# ANTARCTIC SCIENCES

## United States Antarctic Program

The United States Antarctic Program (USAP) encompasses U.S. Government-sponsored activities in the region roughly south of 60° south latitude. NSF funds and manages this national program, which centers on scientific research and includes operational support provided by contractors and the military. The program supports the range of U.S. Antarctic interests, including adherence to the Antarctic Treaty.

USAP-supported research has two thrusts:

1. to understand the Earth and its systems, with emphasis on Antarctica's influence on and response to these systems; and

2. to utilize Antarctica as a research site by supporting studies made possible by the unusual and extreme conditions on the continent and in the surrounding ocean.

USAP supports research that is *best* carried out in the Antarctic, or that can be carried out *only* in the Antarctic.

The Office of Polar Programs Antarctic research support is available through the following programs:

1. **Antarctic Aeronomy and Astrophysics**
2. **Antarctic Biology and Medicine**
3. **Antarctic Geology and Geophysics**
4. **Antarctic Glaciology**
5. **Antarctic Ocean and Climate Systems**
6. **Antarctic Operational Support**

## Non-U.S. Facilities—International Cooperation

NSF encourages scientists from the United States to participate in cooperative research programs and activities sponsored by and involving other Antarctic Treaty nations.

Scientists interested in submitting a proposal for such a program are strongly encouraged to contact an OPP program manager first, to allow NSF time to coordinate the operational support needs with the other participating country or countries.

## Eligibility Requirements for USAP

U.S. academic institutions and academically oriented nonprofit organizations may submit proposals for research support. Industrial firms and State and local agencies may be eligible. Other Federal agencies may coordinate their research needs within the framework of NSF-supported Antarctic logistics.

NSF encourages proposals from all, including women, minorities, and persons with disabilities, and proposals for research that include undergraduates under guidelines established by NSF programs such as Research Experiences for Undergraduates.

Persons selected to work in the Antarctic must pass physical and dental examinations whose standards are specified by USAP. Prospective winterers must pass a psychological examination as well.

## Deadlines and Target Dates for USAP

The annual deadline for receipt of proposals to the U.S. Antarctic Program (Office of Polar Programs) is June 1.

Crosscutting programs and education programs may have different deadlines.

An Operational Requirements Worksheet (available at http://esp.polar.org/) is required if the proposed project will involve fieldwork in the Antarctic, including use of NSF-funded, ice-capable antarctic research ships. These worksheets have a deadline of June 1, 2002, for projects that will take place in the Antarctic beginning in the 2003–2004 austral summer.

To confirm a deadline date, refer to the NSF E-Bulletin (http://www.nsf.gov/home/ebulletin/); the OPP home page, http://www.nsf.gov/od/opp/; or the appropriate program office.

**Literature**

Although NSF program announcements and guidelines remain the primary starting point for individuals interested in applying for NSF support, additional resources are available that can also provide valuable information. A range of literature referencing research priorities for the Antarctic is available on the OPP home page, http://www.nsf.gov/od/opp/. Contact the source indicated.

In addition, the following are also available:

- Publications containing research recommendations, available from the National Academy of Sciences (NAS). Write the Polar Research Board, National Academy of Sciences, 2101 Constitution Avenue, NW, HA-454, Washington, DC 20011; or contact by telephone, 202-334-3479; or visit the NAS home page, http://www.nas.edu/.

- *Antarctic Bibliography*, published by the American Geological Institute (AGI) under cooperative agreement OPP-9909727 with NSF. Search the Antarctic database at http://www.coldregions.org/. Under an agreement between AGI and the National Information Services Corporation (NISC), the *Antarctic Bibliography* and other polar bibliographies are collectively available online at the NISC home page, http://www.nisc.com/Default.htm, and also on CD-ROM.

- The U.S. Geological Survey (USGS), in a joint program with NSF, has Antarctic reconnaissance and geologic maps of portions of Antarctica at various scales; maps of the whole continent; an extensive collection of Antarctic aerial photographs; current and historical handheld photography; and other materials. For more information, visit the USGS United States Antarctic Resource Center web site, http://usarc.usgs.gov/.

- Ice cores, seabed cores, terrestrial sedimentary cores, dredged rocks, biotic specimens, meteorites, and seafloor photographs are available for study. For more information, refer to the *Antarctic Research* program announcement (NSF 01-81).

- NSF's Antarctic Artists and Writers Program supports documentation of America's Antarctic heritage by providing field access (but not funds) to painters, poets, photographers, authors, educational specialists, and representatives of related genres. For complete information about this program, including details on eligibility criteria, visit the Antarctic Artists and Writers Program web site, http://www.nsf.gov/od/opp.

**ⓘ For More Information**

For further information, including the areas of research supported by USAP; material to help proposers evaluate the potential environmental impact of their projects; and descriptions of operational needs in

Antarctica, refer to the *Antarctic Research* program announcement (NSF 01-81).

For questions regarding field operations and logistics to Antarctica, contact the Polar Research Support Section at 703-292-8032; or visit the Raytheon Polar Services Company web site, http://www.polar.org/.

Research and education proposals that will not require fieldwork or that will use samples already in U.S. depositories are welcome.

For further information, contact the Office of Polar Programs, National Science Foundation, 4201 Wilson Boulevard, Room 755, Arlington, VA 22230; or visit the OPP home page, http://www.nsf.gov/od/opp/. Specialists are available in each of the science areas discussed below, as well as in logistics, field camps, research ships, laboratory support, waste management, environmental protection, safety, and Antarctic Conservation Act permits.

**1. Antarctic Aeronomy and Astrophysics—**Supports research projects in the following areas:

- **Astrophysics—**Because of its location at the Earth's spin axis on the 2.8-kilometer-thick East Antarctic Ice Sheet, South Pole Station is well situated for long, continuous astronomical and astrophysical observations. The high elevation of the station (2,835 meters), dry atmosphere, extremely low effective sky temperature, isolation from noise, and long periods of clear weather provide superior observing conditions.

- **Long-Duration Ballooning—**In cooperation with the National Aeronautics and Space Administration, NSF has developed the capability to launch balloon science payloads from McMurdo Station. These payloads weigh more than a ton and can reach altitudes of approximately 40 kilometers. The balloons then drift once or twice over the South Pole during a 10- to 30-day period. This capability can be used by several disciplines and in some cases can serve as a low-cost substitute for space flight.

- **Upper Atmosphere Physics—**Supports unique studies of the Earth's magnetosphere and ionosphere and of Sun/Earth relationships. Year-round station-based research is possible in Antarctica because of its physically stable location at high geomagnetic latitudes, which range from 53° south at Palmer Station to 79° south at McMurdo Station. Automatic Geophysical Observatories provide year-round support for low-powered autonomous instruments at several remote sites on the ice sheet. Research objectives include improving the understanding of Earth's upper atmosphere and near-space environment; investigating coupling among the neutral atmosphere, the ionosphere, and the magnetosphere; and investigating solar terrestrial effects.

**2. Antarctic Biology and Medicine—**Supports research projects in the following areas:

- **Marine Biology/Biological Oceanography—**Supports research on the oceans around Antarctica, which make up one of the world's more productive marine regions. Research objectives are to understand the structure and function of the Antarctic marine ecosystems and to determine the adaptations of organisms and acquire more knowledge of their distribution, abundance, and dynamics. The major focus is on ship- and shore-based studies that stress trophodynamics, including detailed investigations at all trophic levels. Topics of particular interest include interdisciplinary studies of carbon and nutrient cycling, krill, ice-

edge ecosystems, and low-temperature adaptations.

- **Medical Research—**Biomedical studies are directed toward physiological and psychological attributes and adaptations of people in small, isolated groups.

- **Terrestrial and Freshwater Biology—**Biota of terrestrial and freshwater Antarctica, particularly their adaptation to the extreme environment, are of particular interest. The simplicity of these ecosystems provides opportunities for analysis that is more difficult and sometimes impossible in the complex systems of the lower latitudes. The primary research objective is to understand the effects of the physical environment on the biota and adaptations of organisms, and to gain further knowledge of their distribution, abundance, and dynamics.

**3. Antarctic Geology and Geophysics—** Supports research projects in the following areas:

- **Marine Geology and Geophysics—** The seafloor around Antarctica is complex and presents fundamental problems in marine geology and geophysics. Its sediments provide detailed records of changes over time in the size of the Antarctic ice sheet, as well as clues to other geological and tectonic processes that have affected the continent. Research objectives are to interpret geological and glacial history and to understand geological processes from studies of the continental margins and the adjacent oceanic crust.

- **Terrestrial Geology and Geophysics—**Antarctica represents about 9 percent of the Earth's continental crust and has been in a near-polar position for more than 100 million years. Reconnaissance studies have led to increased understanding of many general aspects of the geology of the continent, and major evidence has developed in support of plate tectonics models and of the Gondwana supercontinent. Antarctic geology has entered an era in which focused projects can contribute to solving regionally and globally significant geologic problems. Geophysical investigations of the sub-ice bedrock have become a prominent part of the program. Aerogeophysical research, involving acquisition of such data as surface elevation, ice thickness, and magnetic and gravity data, can be supported as self-contained projects. Satellite imagery also is contributing to research in these areas. Over-snow seismic capabilities are anticipated for the future. Overall objectives of the program are to explain the geology and geological evolution of Antarctica, to understand the relationship of Antarctica to global geodynamic systems, and to exploit unique aspects of Antarctica to address fundamental problems in geology and geophysics.

**4. Antarctic Glaciology—**Supports studies of the world's largest ice sheet. The ice sheet, which covers 97 percent of the Antarctic continent and is up to 4.8 kilometers thick, comprises 90 percent of the world's ice and is a storehouse of information about climate and atmospheric constituents and their variation over time. The program's objectives are to determine the dynamics of the ice sheet, understand the climatic record stored in the layers of firn and ice, determine the history of glacial advance and retreat through the study of glacial/geologic deposits, and determine the present dynamic status of the ice sheet and its relationship to glacial and climatic history.

**5. Antarctic Ocean and Climate Systems—**Supports research projects in the following areas:

- **Atmospheric Sciences—**Antarctica interacts strongly with regional and global weather and climate. Far removed from pollution sources, it is an important monitoring and research area for world background levels of natural and anthropogenic atmospheric constituents. Conditions in Antarctica to reflect global atmospheric changes on many scales. The primary research objectives are to improve understanding of the physical processes of the atmosphere; determine the relationship between events and conditions in the Antarctic atmosphere and global events; and assess the region's role in past and present global climate.

- **Physical and Chemical Oceanography—**Supports research on the Southern Ocean, which has a central role in world ocean circulation. Large-scale heat exchange and ice formation at the ocean surface overturn the water column and mix trace constituents, making the Southern Ocean the site of global-scale deep-ocean ventilation and one of two primary sources (the other being the Arctic) of the world's intermediate and deep-water masses. Huge changes in the extent of sea ice, which varies annually between 4 and 20 million square kilometers, also influence energy transfer. The Antarctic Circumpolar Current, the world's largest ocean current, has a primary role in general oceanic circulation. Research objectives are to determine the dynamics of formation and distribution of water masses, currents, and sea ice; investigate the relationships among oceanic and atmospheric circulation systems and the physical bases for biotic productivity; and investigate interactions between the Southern Ocean and climate processes.

**6. Antarctic Operational Support—**In addition to funding research, USAP provides operational and laboratory support in Antarctica. Operational support includes the following: a year-round inland research station at the South Pole (90°S.); two year-round coastal research stations with extensive laboratory and computing capabilities—one at McMurdo Station (78°S.) on Ross Island and one at Palmer Station (64°S.) on Anvers Island in the Antarctic Peninsula region; summer field camps for research, as required; the ice-strengthened research ship *Laurence M. Gould*, 70.1 meters in length; the icebreaking research ship *Nathaniel B. Palmer*, 94 meters in length; ski-equipped LC-130 airplanes (for heavy-lift transport); other airplanes; helicopters; a Coast Guard icebreaker for channel breaking at McMurdo as well as research support; over-snow vehicles; and automated, unmanned weather and geophysical observatories. Occasionally, vessels from the U.S. academic fleet and from the Ocean Drilling Program support Antarctic research. NSF-supported research by U.S. scientists also can be carried out as an international collaboration aboard non-U.S. research ships.

Air transport between New Zealand and McMurdo Station is provided several times per week in the austral summer, which runs from early October to the end of February. From McMurdo, a logistics hub, research groups can access other sites, including the station at the South Pole. Several flights are made in August between New Zealand and McMurdo that provide an opportunity for late winter access. The summer camps are closed between February and October, and winter research is limited to the immediate environs of the stations, where residents are isolated for as long as 8 months. Consideration is being given to lengthening the operating season at and near McMurdo, and proposals that would take advantage of this change are welcome.

Palmer Station, on Anvers Island in the Antarctic Peninsula region, relies mainly on the ship *Laurence M. Gould* for transport of people and materials to and from Punta Arenas, Chile, at the southern tip of South America. The ship makes several trips a year and supports onboard research. The *Gould* supports onboard research in marine biology, oceanography, and geophysics in the Antarctic Peninsula region and can support science in other areas of the Southern Ocean.

U.S. Antarctic stations and ships and some field camps provide voice and data communications, including Internet access, to locations outside Antarctica. See the *Antarctic Research* program announcement (NSF 01-81) for instructions on how to request Antarctic operational support in a proposal.

# ARCTIC SCIENCES

### Arctic Research Program

NSF's Arctic Research Program seeks to gain a better understanding of Arctic biological, geological, chemical, and sociocultural processes and the interactions of ocean, land, atmosphere, life, and human systems—both in the Arctic and with global systems. Arctic research is supported by the Office of Polar Programs (OPP) and by other NSF disciplinary programs. The program is structured to allow coordination across NSF disciplines when appropriate, and to enable joint review and funding of Arctic proposals and mutual support of projects with high logistics costs.

The United States Arctic Research and Policy Act of 1984 defines the Arctic as all areas north of the Arctic Circle and all U.S. territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas including the Arctic Ocean and the Beaufort, Bering, and Chukchi Seas; and the Aleutian chain. Field projects falling outside these boundaries but directly related to Arctic science and engineering conditions or issues, such as laboratory and theoretical studies, are appropriate.

NSF is one of 12 Federal agencies that sponsor or conduct Arctic science, engineering, and related activities. As mandated by the Arctic Research and Policy Act of 1984, planning for Federal interagency research is coordinated through the Interagency Arctic Research Policy Committee, chaired by NSF.

Further information on other agency programs is presented in the *U.S. Arctic Research Plan* and its biennial revisions.

The Arctic is the homeland of native peoples, and attention must be given to all aspects of research and education that may potentially affect their lives. For more information, see the interagency statement, "Principles for the Conduct of Research in the Arctic," at http://www.nsf.gov/od/opp/arctic/conduct.htm. All Arctic research grantees are expected to abide by these guidelines. See also *Arctic Research Opportunities* (NSF 00-96).

The Arctic Research Program is composed of the following:

1. **Arctic Natural Sciences**
2. **Arctic Social Sciences**
3. **Arctic System Science**
4. **Other Arctic Support**

### Target Dates for Arctic Research

The target dates for the Arctic Natural Sciences, Arctic Social Sciences, and Arctic System Science Programs are February 15 and August 8. Proposals for workshops,

Small Grants for Exploratory Research, or dissertation improvement grants can be submitted at any time. Further information about these types of grants is available in the NSF *Grant Proposal Guide* (see http://www.nsf.gov/cgi-bin/getpub?gpg for the latest version).

### Submission of Proposals for Arctic Research

Submit proposals for field projects (including projects requiring an oceanic research vessel) by February 15 of the year preceding fieldwork.

A minimum of 9 months' advance notice is required for research vessels needing clearance for Russian waters.

For fieldwork in Greenland, fill out the Danish Polar Center application form (see http://www.dpc.dk/Guide) and put it in Supplementary Docs in the FastLane proposal submitted to OPP.

### ⓘ For More Information

Further information about any of the Arctic programs and activities mentioned in this section is available in the publication, *Arctic Research Program Opportunities* (NSF 00-96). Additional information can also be obtained by contacting the Office of Polar Programs, National Science Foundation, 4201 Wilson Boulevard, Room 755, Arlington, VA 22230; or by visiting the OPP home page, http://www.nsf.gov/od/opp/.

**1. Arctic Natural Sciences—**Supports research in glaciology; atmospheric, biological, earth, and ocean sciences; and contaminants. The program provides core support for disciplinary research in the Arctic and coordinates its support of Arctic research with the Directorates for Geosciences and Biological Sciences.

Areas of special interest include marine and terrestrial ecosystems, atmospheric chemistry, exploration of the Arctic Ocean, and Arctic geological and glaciological processes. The program supports research in the following areas:

- **Atmospheric Sciences—**Focuses on stratospheric and tropospheric processes; Arctic climate and meteorology; research on past climates and atmospheric gases, as preserved in snow and ice cores; and research on atmosphere/sea and atmosphere/ice interactions. In the area of upper atmospheric and space physics, research interests include auroral studies, atmospheric dynamics and chemistry, and magnetosphere-ionosphere coupling. Conjugate studies are considered jointly with the Antarctic Aeronomy and Astrophysics Program.

- **Biological Sciences—**Supports projects that emphasize understanding the adaptation of organisms to the Arctic environment. Biological studies in the Arctic include research on freshwater, marine, and terrestrial biology; organismal adaptation to the Arctic environment; ecology; ecosystem structure and processes; and the biological consequences of ultraviolet radiation.

- **Earth Sciences—**Supports research in all subdisciplines of terrestrial and marine geology and geophysics, with special emphasis on understanding geological processes important to the Arctic regions and geologic history dominated by those processes.

- **Glaciology—**Supports glaciological research, which is concerned with the history and dynamics of all naturally occurring forms of snow and ice, including seasonal snow, glaciers, and the Greenland ice sheet. The Arctic Natural Sciences Program also includes

ice dynamics, modeling, glacial geology, and remote-sensing studies of ice sheets. OPP is the focal point for glaciological research within NSF.

- **Ocean Sciences—**Seeks to develop knowledge of the structure of the Arctic Ocean and adjacent seas, their physical and biological interactions with the global hydrosphere, and the formation and persistence of the Arctic sea/ice cover. Special interest areas include the distribution of life in high-latitude oceans; low-temperature life processes; the formation, movement, and mixing of Arctic water masses; the growth and decay of sea ice; the exchange of salt and heat with the Atlantic Ocean and the Bering Sea; geographical anomalies; sedimentary history; and the role of the Arctic Ocean and adjacent seas in the global climate. Proposals concerned with the interdependencies of chemical and physical processes and marine organisms and productivity are encouraged.

- **Contaminants—**Supports research on the physical, chemical, and biological processes that sequester and disperse contaminants in Arctic natural systems and on the socioeconomic impacts of and human response to such contaminants. Quantification of these processes for a variety of contaminants—including heavy metals, radionuclides, persistent organic pollutants (e.g., pesticides, industrial chemicals), hydrocarbons, ozone (and precursors), and aerosols derived from various parts of the Arctic and other U.S., European, and former Soviet Union sites—is fundamental to appreciating and mitigating their impact on human physical and socioeconomic systems.

**2. Arctic Social Sciences—**Encompasses all social sciences supported by NSF, including anthropology, archaeology, economics, geography, linguistics, political science, psychology, sociology, and related subjects. Unsolicited proposals in any of these social sciences are welcome. Areas of particular interest include rapid social change, including the processes and consequences of social, economic, and cultural change; community viability, including issues related to community and cultural vitality and survival; and human/environment interactions, including issues related to subsistence and sustainable development.

The program encourages projects that include indigenous peoples; are circumpolar or comparative; integrate social and natural sciences; involve collaborations between researchers and those living in the Arctic; include traditional knowledge; or form connections among disciplines, regions, researchers, communities, and students, including those in grades K–12 and undergraduate and graduate programs.

The Arctic Social Sciences Program considers joint review and funding with other programs within OPP and within other NSF directorates when appropriate. Special funding opportunities may also be available through NSF's Environment and Global Change activities (for more information, see the Crosscutting Investment Strategies section of this Guide) or the Arctic System Science Program (see program description elsewhere in this section).

**Projects Involving Human Subjects**

Projects involving research with human subjects must ensure that subjects are protected from research risks in conformance with the Common Rule (*Federal Policy for the Protection of Human Subjects,* 45 CFR §690). All projects involving human subjects must either (1) have approval from the organization's Institutional Review Board (IRB) before issuance of an NSF award; or (2) identify the applicable subsection exempting the proposal from IRB review, as established in section 101(b) of the Common Rule. The

box for "Human Subjects" should be checked on the NSF Form 1207 with the IRB approval date (if available) or exemption subsection from the Common Rule identified in the space provided.

**3. Arctic System Science (ARCSS)—**The overall goals of the ARCSS Program are to understand the physical, geological, chemical, biological, and sociocultural processes of the Arctic system that interact with the total Earth system and thus contribute to or are influenced by global change; to advance the scientific basis for predicting environmental change on a seasonal-to-centuries time scale; and to formulate policy options in response to the anticipated impacts of global change on humans and societal support systems. To achieve these goals, ARCSS places strong emphasis on four scientific thrusts: (1) to understand global and regional impacts of the Arctic climate system and its variability; (2) to determine the role of the Arctic in global biogeochemical cycling; (3) to identify global change impacts on the structure and stability of Arctic ecosystems; and (4) to establish links between environmental change and human activity.

Most of the available support in ARCSS is directed toward large integrated research projects that are proposed and implemented in response to scientific plans developed by the science community through Science Steering Committees for each component of ARCSS. However, global change proposals from individual investigators or small groups of investigators are also welcome.

ARCSS has three linked components for which proposals are encouraged:

- Ocean/Atmosphere/Ice Interactions (OAII) (see the OAII web page, http://arcss.colorado.edu/projects/oaii.html);

- Land/Atmosphere/Ice Interactions (LAII) (see the web home page, http://arcss.colorado.edu/projects/laii.html); and

- Paleoenvironmental Arctic Sciences (PARCS) (see the PARCS home page, http://arcss.colorado.edu/arcss/projects/parcs.html).

ARCSS further develops a fourth component, Human Dimensions of the Arctic System (HARC) (see program announcement NSF 99-61). The science plan for HARC is available on the Arctic Research Consortium of the United States (ARCUS) home page, http://www.arcus.org/, and on the OPP home page, http://www.nsf.gov/od/opp/. These sites should be consulted for new developments. In all these components, proposals for new and different research topics are encouraged.

ARCSS also supports the integration of research results across components within the program and with any other Arctic research program through a Synthesis, Integration, and Modeling Studies (SIMS) effort. Science plans approved by each Science Steering Committee, as well as examples of projects supported within each component and SIMS, are accessible on either the web site maintained by the ARCSS Data Coordination Center at the University of Colorado National Snow and Ice Data Center, http://arcss.colorado.edu/, or the ARCUS home page.

The Arctic system consists of physical, biological, and cultural factors that may respond to global change. Some models that predict the climatic response to global change show greater change in the Arctic than in any other region. The predicted climatology, however, may not consider the largely unknown interannual variability in the Arctic. The presence of cultural institutions in a region subject to possibly large

perturbations makes it important that scientists better understand interactions of the global and arctic systems. Therefore, the research supported in ARCSS extends beyond purely observational studies to studies that predict and analyze the consequences of global change that are important to wise stewardship of renewable resources and development of policy options for resource managers and residents.

In order to focus on the Arctic system at a scale that incorporates the multiple environmental feedback mechanisms involved, large interdisciplinary projects that integrate major elements of the system will be supported. For more information on how a research proposal might best fit the programs and themes of ARCSS, contact a program manager.

**4. Other Arctic Support—**The following additional NSF programs and activities also offer research support in the Arctic Research Program.

- **Arctic Research Support and Logistics (RSL)—**The RSL Program has been established in OPP to address all field program requirements. The primary means of accessing this support is through the regular proposal process. Investigators should be able to justify the field support in the context of their proposal and are encouraged to consider the following in particular: increased mobility to and within the Arctic; increased safety potential of satellite-based global phone networks; use of field staff trained and experienced in field (and boat) safety and first aid; increased interaction with local communities; and use of equipment improved for use during fieldwork in Arctic conditions.

  Support for grantees from the RSL Program includes food and shelter during the course of the fieldwork; user- and day-rate fees; salaries of staff hired specifically for fieldwork; and the steps necessary to coordinate projects with permitting agencies and native peoples.

  A brief section within the proposal and in the budget explanation should outline the field plan and associated costs. If a third party (e.g., VECO, see below) is going to provide support, then those costs do not need to be included in the proposal budget.

  The program manager from the program supporting the research, in consultation with the manager of the program, will determine the level of support that can be provided by RSL. In some cases, OPP may determine that several unrelated proposals can derive significant cost benefits from a centrally managed resource. If so, NSF's Arctic Support Contractor (VECO Polar Resources) or another entity will be responsible for coordinating the support with the principal investigators, consistent with the agreements between the investigators and their program managers. Work also can be proposed as a large coordinated activity, supported at some level by the science team or a support contractor.

  The Barrow Arctic Science Consortium supports work at most sites on Alaska's North Slope. The Institute of Arctic Biology at the University of Alaska supports work at Toolik Field Station (see http://www.uaf.edu/toolik/). The contractor manages support at most other Arctic sites, including use of military airlift; support to and within Greenland; and support in Arctic Alaska. The contractor can provide additional information and can coordinate with other nations' logistics providers, such as Canada's Polar Continental Shelf Program.

  Investigators are encouraged to discuss support options with the Arctic contractor, VECO Polar Resources

(http://www.veco.com/vpr), before they prepare proposals. All work should be described in the proposal.

- **Arctic Research and Policy—**OPP supports the management of Arctic data and information. The objective is to make data and information resources more readily available to researchers. Proposals to integrate data and information management are encouraged. Further information is available at the National Information Services Corporation home page, http://www.nisc.com/request/bibltrial.asp.

## CROSSCUTTING PROGRAMS

Because the Office of Polar Programs supports research in several disciplines, a number of NSF-supported programs that cross traditional disciplinary boundaries will be of interest to investigators planning polar research and education projects.

These crosscutting programs offer significant additional opportunities for support. OPP strongly urges investigators considering polar research to examine the programs before submitting proposals.

### ⓘ For More Information

Visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm/.

# SOCIAL, BEHAVIORAL, AND ECONOMIC SCIENCES

The goals of the Directorate for Social, Behavioral, and Economic Sciences (SBE) are to develop basic scientific knowledge of human social behavior, interaction, and decisionmaking and of social and economic systems, organizations, and institutions; to collect, analyze, and publish data on the status of the Nation's science and engineering human, institutional, and financial resources; and to advance the U.S. science and engineering enterprise by promoting international partnerships and by enhancing the work of U.S. researchers through cooperative activities with foreign scientists and engineers and their facilities and institutions.

The Directorate for Social, Behavioral, and Economic Sciences supports programs and activities through the following:

- **Crosscutting Programs and Activities**
- **Division of Behavioral and Cognitive Sciences (BCS)**
- **Division of Social and Economic Sciences (SES)**
- **Division of Science Resources Statistics (SRS)**
- **Division of International Programs (INT)**

### ⓘ For More Information

Visit the SBE Directorate home page, http://www.nsf.gov/sbe/.

# CROSSCUTTING PROGRAMS AND ACTIVITIES

In addition to supporting the programs and activities within the Directorate for Social, Behavioral, and Economic Sciences (SBE), SBE also takes an active role in the following crosscutting programs and activities:

- **Priority Areas**
  - **–Information Technology Research**
  - **–Biocomplexity in the Environment**
  - **–Learning for the 21st Century**

- **National Science and Technology Council Crosscuts**
  - **–High Performance Computing and Communications and Information Technology**
  - **–U.S. Global Change Research**

### ⓘ For More Information

Visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm/.

# DIVISION OF BEHAVIORAL AND COGNITIVE SCIENCES

Research support is available in the Division of Behavioral and Cognitive Sciences (BCS) through the following clusters of programs:

- **Anthropological and Geographic Sciences Cluster**
- **Cognitive, Psychological, and Language Sciences Cluster**

### Submission of Proposals to the BCS Division

All programs in the BCS Division consider proposals for research projects, conferences, and workshops. Some programs also consider proposals for doctoral dissertation improvement, the acquisition of specialized research and computing equipment, and large-scale data collection.

BCS conducts special initiatives and competitions on a number of topics such as cognitive neuroscience; children's research; human origins; environmental, social, and behavioral sciences; and integrative graduate education and research training.

### ⓘ For More Information

Write to the responsible program director, Division of Behavioral and Cognitive Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 995, Arlington, VA 22230; or contact by telephone, 703-292-8740; or visit the BCS home page, http://www.nsf.gov/sbe/bcs/start.htm.

## ANTHROPOLOGICAL AND GEOGRAPHIC SCIENCES CLUSTER

This cluster of programs is within the Division of Behavioral and Cognitive Sciences (BCS) and is composed of the following:

1. **Archaeology and Archaeometry**
2. **Cultural Anthropology**

3. **Geography and Regional Science**
4. **Physical Anthropology**

### ⓘ For More Information

Visit the BCS Division home page, http://www.nsf.gov/sbe/bcs/start.htm.

**1. Archaeology and Archaeometry—** Supports archaeological research that contributes to an anthropological understanding of the past. Both fieldwork and nonfieldwork are eligible for support. Through a special archaeometry competition, the program provides support for projects that conduct archaeometric work of anthropological significance and that develop archaeometric techniques.

**2. Cultural Anthropology—**Supports basic research on the causes and consequences of crosscultural and intracultural variation as such research broadens or refines anthropological theory. In an effort to enhance the quality of students' field research in graduate programs, the program offers Ethnographic Research Training Awards. Scholars' Awards in Methodological Training for Cultural Anthropologists are offered for senior researchers who wish to upgrade their research skills by learning a particular analytical technique.

**3. Geography and Regional Science—** Supports basic research on the causes and consequences of geographical differences in economic, social, cultural, and physical phenomena, including interactions among places and regions and interrelations between human activities and the natural environment. Projects on a variety of domestic and overseas topics that will enhance geographical theory, geographical methods, and its applications qualify for support.

**4. Physical Anthropology—**Supports basic research in areas that relate to human evolution and contemporary human variation. Research areas supported by the program include human genetic variation, human adaptation, human osteology, human origins, human paleontology, primate functional anatomy, and primate behavior.

## COGNITIVE, PSYCHOLOGICAL, AND LANGUAGE SCIENCES CLUSTER

This cluster of programs is within the Division of Behavioral and Cognitive Sciences (BCS) and is composed of the following:

1. **Developmental and Learning Sciences**
2. **Human Cognition and Perception**
3. **Linguistics**
4. **Social Psychology**
5. **Cognitive Neuroscience**

### ⓘ For More Information

Visit the BCS Division home page, http://www.nsf.gov/sbe/bcs/start.htm.

**1. Developmental and Learning Sciences—**Supports research on cognitive, social, and biological processes related to children and adolescent learning in formal and informal settings. Priorities are to support research on learning and development that incorporates multidisciplinary, multimethod, microgenetic, and longitudinal approaches; develops new methods and theories; examines transfer of knowledge from one domain to another; assesses peer relations, family interactions,

social identities, and motivation; examines the impact of family, school, and community resources; assesses adolescents' preparation for entry into the workforce; and investigates the role of culture in children's learning and development.

**2. Human Cognition and Perception—** Supports research on human perceptual and cognitive processes, including the development of these processes. Emphasis is on research strongly grounded in theory. Research topics include vision, audition, haptic perception, attention, object recognition, language processing, spatial representation, motor control, memory, reasoning, and concept formation. The program encompasses a wide range of theoretical perspectives such as experimental computation, connectionism, and ecological perception and a variety of methodologies such as experimental studies and computational modeling. Research involving acquired or developmental deficits is appropriate if the results speak to basic issues in the study of normal perception or cognition.

**3. Linguistics—**Supports theoretically informed research on human language. The program encompasses a wide range of theoretical perspectives and a variety of methodologies, including experimental studies and computational modeling. Research topics include the properties of individual languages and of language in general; language acquisition; the psychological processes involved in the use of language; social and cultural factors in language use, variation, and change; acoustic, articulatory, and perceptual study of speech; and the biological bases of language in the central nervous system. Program awards have also supported the development of lexicons, corpora, databases, and other resources for the language sciences. In addition to regular research proposals, the program accepts proposals for doctoral dissertation research; conferences, workshops, and symposia; group travel to international conferences; and Small Grants for Exploratory Research.

**4. Social Psychology—**Supports research on human social behavior, including cultural influences and life-span social development. Research topics include aggression; altruism; attitude formation and change; attitudes and behavior; attributional processes; emotion; environmental psychology; group decisionmaking, performance, and process; intergroup relations; interpersonal attraction and relations; nonverbal communication; person perception; personality processes; prejudice; the self; social comparison; social cognition; social influence; and stereotyping.

**5. Cognitive Neuroscience—**Supports neuroscientific research on cognitive, perceptual, linguistic, developmental, affective, and social processes, including developmental and computational modeling approaches. Priorities of the program are to support collaborative research and to enhance training at all levels of professional development.

## DIVISION OF SOCIAL AND ECONOMIC SCIENCES

Research support is available in the Division of Social and Economic Sciences (SES) through the following clusters of programs:

- **Economic, Decision, and Management Sciences Cluster**
- **Methods, Cross-Directorate, and Science and Society Cluster**
- **Social and Political Sciences Cluster**

**Submission of Proposals to the SES Division**

All programs in the SES Division consider proposals for research projects, conferences, and workshops. Some programs also consider proposals for doctoral dissertation improvement, the acquisition of specialized research and computing equipment, and large-scale data collection.

SES conducts special initiatives and competitions on a number of topics such as human dimensions of global change, learning and intelligent systems, integrative graduate education and research training, and human capital.

**ⓘ For More Information**

Write to the responsible program director, Division of Social and Economic Sciences, National Science Foundation, 4201 Wilson Boulevard, Room 99, Arlington, VA 22230; or contact by telephone, 703-292-8760; or visit the SES home page, http://www.nsf.gov/sbe/ses/start.htm.

## ECONOMIC, DECISION, AND MANAGEMENT SCIENCES CLUSTER

This cluster of programs is within the Division of Social and Economic Sciences (SES) and consists of the following:

1. **Decision, Risk, and Management Science**
2. **Economics**
3. **Innovation and Organizational Change**

**ⓘ For More Information**

Visit the SES Division home page, http://www.nsf.gov/sbe/ses/start.htm.

**1. Decision, Risk, and Management Science—**Supports scientific research directed at increasing the understanding and effectiveness of decisionmaking by individuals, groups, organizations, and society. Disciplinary and interdisciplinary research, doctoral dissertation research, and workshops are funded in the areas of judgment and decisionmaking; decision analysis and decision aids; risk analysis, perception, and communication; societal and public policy decisionmaking; and management science and organizational design. The program also supports small grants for exploratory research that are time-critical, such as decisionmaking in response to extreme events. Funded research must have implications in an operational or applied context, be grounded in theory, be based on empirical observation or subject to empirical validation, and be generalizable. The program conducts a special joint NSF/private-sector initiative, through which NSF funding is matched by contributions from private firms, to conduct basic research that is firmly grounded in real and practical contexts.

**2. Economics—**Supports basic scientific research designed to improve the understanding of the processes and institutions of the U.S. economy and of the world system of which it is a part. The program supports empirical and theoretical research as well as conferences in almost every subfield of economics, including econometrics, mathematical economics, labor economics, macroeconomics, industrial organization, international economics, public finance, and economic history. The program also supports interdisciplinary research and conferences that strengthen the connection between economics and other disciplines, including the other social sciences, statistics, mathematics, the behavioral sciences, and engineering.

**3. Innovation and Organizational Change (IOC)—**Seeks to improve the performance of industrial, educational, service, health care, government, and other organizations and institutions. Proposers work in partnership with organizations in these areas to perform research on theories, concepts, and methodologies of innovation and organizational change. The program supports research using theory combined with empirical validation to understand effective approaches to organizational learning and redesign, strategic change, and cultural change; quality and process improvement; innovation and change management; new product and service development; and the development and integration of new technologies.

Three NSF directorates jointly support the program: Social and Economic Sciences; Engineering; and Education and Human Resources. The IOC Program supersedes and extends the scope of two previous NSF programs: Management of Technological Innovation (MOTI) and Transformations to Quality Organizations (TQO).

## METHODS, CROSS-DIRECTORATE, AND SCIENCE AND SOCIETY CLUSTER

This cluster of programs is within the Division of Social and Economic Sciences (SES) and is composed of the following:

1. **Cross-Directorate Activities**
2. **Methodology, Measurement, and Statistics**
3. **Science and Technology Studies**
4. **Societal Dimensions of Engineering, Science, and Technology: Ethics and Values Studies, Research on Science and Technology**

### ⓘ For More Information

Visit the SES Division home page, http://www.nsf.gov/sbe/ses/start.htm.

**1. Cross-Directorate Activities—** Provides information about various cross-directorate programs in which the Social, Behavioral, and Economic Sciences Directorate participates. For activities related to the social and behavioral sciences, the program administers the Research Experiences for Undergraduates Sites, ADVANCE Fellows, and Minority Postdoctoral Research Fellowships Programs. In addition, the program coordinates the Faculty Early Career Development, Presidential Early Career Awards for Scientists and Engineers, Research Opportunity Awards, Integrative Graduate Education and Research Traineeships, and Small Business Innovation Research Programs. Also in the areas of social and behavioral sciences, the program officers for Cross-Directorate Activities can provide information about special opportunities NSF offers for education initiatives. For a complete description of these programs, see the Crosscutting Investment Strategies section in this Guide.

### ⓘ For More Information

See Chapter 1, “Crosscutting Investment Strategies,” in this Guide; or visit the NSF Crosscutting Programs home page, http://www.nsf.gov/home/crssprgm/start.htm, or the SES Division home page, http://www.nsf.gov/sbe/ses/ip.

**2. Methodology, Measurement, and Statistics—**Supports fundamental research on the development, application, and extension of formal models and methodologies for social and behavioral

research, including methods for improving measurement, and research on statistical methodology or statistical modeling that has direct implications for one or more of the social and behavioral sciences. Also supported are research on methodological aspects of new or existing procedures for data collection; research to evaluate or compare existing databases and data collection procedures; the collection of unique databases with cross-disciplinary implications, especially when paired with developments in measurement or methodology; and the methodological infrastructure of social and behavioral research.

**3. Science and Technology Studies—** Supports historical, philosophical, cognitive, and social research regarding the character and development of science and technology; the nature of theory and evidence in different fields; and the social and intellectual construction of science and technology. Support is also given to research that examines the relationship among science, government, and other social institutions and groups, and processes of scientific innovation and change.

**4. Societal Dimensions of Engineering, Science, and Technology: Ethics and Values Studies, Research on Science and Technology—**Includes Ethics and Values Studies (EVS) and Research on Science and Technology (RST). The EVS component focuses on improving knowledge about ethical and value dimensions in science, engineering, and technology. The RST component focuses on improving approaches and information for decisionmaking about investment in science, engineering, and technology.

## SOCIAL AND POLITICAL SCIENCES CLUSTER

This cluster of programs is within the Division of Social and Economic Sciences (SES) and consists of the following:

1. **Law and Social Science**
2. **Political Science**
3. **Sociology**

### ⓘ For More Information

Visit the SES Division home page, http://www.nsf.gov/sbe/ses/start.htm.

**1. Law and Social Science—**Supports social science studies of law and lawlike systems of rule, institutions, processes, and behavior. These studies may include research designed to enhance the scientific understanding of the impact of law; human behavior and interaction as they relate to law; the dynamics of legal decision making; and the nature, source, and consequence of variation and change in legal institutions. The primary consideration is that the research shows promise of advancing the scientific understanding of law and legal process. Within this framework, the program has an “open window” for diverse theoretical perspectives, methods, and contexts for study.

**2. Political Science—**Supports scientific research that advances knowledge and understanding of citizenship, government, and politics. Research proposals are expected to be theoretically motivated, conceptually clear, methodologically rigorous, and empirically oriented. Substantive areas for research proposals include American government and politics, comparative government and politics, international relations, political behavior, political economy, and political institutions.

In recent years, program awards have supported research projects on bargaining processes; campaigns and elections, electoral choice, and electoral systems; citizen support in emerging and established democracies; democratization, political change, and regime transitions; domestic and international conflict; international political economy; party activism; political psychology and political tolerance. On occasion, program awards also have supported research experiences for undergraduate students, methodological advances in political science, and infrastructural improvements through conference activities.

**3. Sociology—**Supports scientific research on all forms of human social organization—societies, institutions, groups, and demography. The program encourages theoretically focused empirical investigations of social processes and social structures. It welcomes research that will build connections with other disciplines. Recent awards supported by the program include research on assimilation; crime and delinquency; democratization; education; family; gender; group processes; migration and immigration; organizations and organizational behavior; race and ethnic relations; religion; science and technology; social networks; social movements; stratification and mobility; voluntary organizations; and work and labor markets. The program also promotes doctoral research through Dissertation Improvement Grants (for more information on these grants, refer to the NSF *Grant Proposal Guide* [see http://www.nsf.gov/cgi-bin/getpub?gpg for latest version]).

# DIVISION OF SCIENCE RESOURCES STATISTICS

The Division of Science Resources Statistics (SRS) provides statistical data on the science and engineering enterprise: education, workforce, research and development funding, and research facilities. The data enables policy-makers, researchers, and the public to better understand our Nation's science, engineering, and technology enterprise. SRS contracts for most of the data collection activities and some of the analyses that it handles.

The SRS Division encourages proposals for research, workshops, and studies that will lead to the development of new and improved science and technology (S&T) indicators and to an improved understanding of the S&T enterprise in the United States and globally. SRS also invites new approaches to the presentation of indicators that will both increase the understanding of S&T issues and permit more sophisticated techniques of statistical analysis and electronic display.

**Proposal Submission**

The SRS Division welcomes the submission of proposals to its programs in the topic areas mentioned in this Guide. For specific information and instructions on proposal submission, see the program announcement *Grants for the Analysis of Science and Technology Resources* (NSF 00-111). Proposals are due in mid-September. Awards are made in March of the following year.

### SRS Documents

Using data from its surveys, the SRS Division produces numerous reports on important topics in science, engineering, and technology. The following are examples of widely referenced SRS publication series:

- *Science and Engineering Indicators*
- *Women, Minorities, and Persons with Disabilities in Science and Engineering*
- *National Patterns of R&D Resources*
- *Science and Engineering Research Facilities*
- *Science and Engineering Doctorate Awards*

Also available are special reports and data and issue briefs on topics related to the science, engineering, and technology enterprise. Data products such as microdata files are made available to the research community. To help acquaint customers with SRS products and databases, the division has an extensive web site presenting its full collection of reports, public-use microfiles, and online data systems.

### ⓘ For More Information

Visit the SRS home page, http://www.nsf.gov/sbe/srs/; or contact the division by telephone, 703-292-8774.

# DIVISION OF INTERNATIONAL PROGRAMS

Research and education in science and engineering benefit immensely from international cooperation. The Division of International Programs (INT) enables and encourages U.S. scientists, engineers, and their institutions to avail themselves of opportunities to enhance their research and education programs through international cooperation. NSF also provides opportunities for future generations of U.S. scientists and engineers to gain the experience and outlook they will need to function productively in an international research and education environment.

### Submission of Proposals to the INT Division

The INT Division works closely with the disciplinary research divisions of NSF. Depending on the circumstance, a proposal may be submitted to INT or to the appropriate disciplinary division, or supplements to existing grants may be requested. Principal investigators who are considering applying for an INT supplement should discuss the scope and timeframe of their proposed activity with both the cognizant program manager in the disciplinary research division and the appropriate (normally, geographically based) program manager in INT.

The INT Division typically supports the travel and incremental international living costs of the U.S. participants in the activity. Further information such as special considerations and funding provisions for certain geographical regions or countries can be found on the INT Division home page, http://www.nsf.gov/sbe/int/start.htm, and in the program announcement *International Opportunities for Scientists and Engineers* (NSF 00-138).

### Eligibility Requirements for the INT Division

Proposals from U.S. scientists and engineers for international activities are eligible for consideration in all fields of science and engineering supported by NSF.

Normally a proposal must be submitted by a U.S. institution, with the exception of International Research Fellow awards and the Japan and Korea Summer Programs, which accept applications from individuals who are U.S. citizens or permanent residents. Proposals submitted to the INT Division normally compete in one of five regional groupings. Proposals for International Research Fellow awards are in a separate competition.

## ⓘ For More Information

Contact the relevant program office listed below or write to the Division of International Programs, National Science Foundation, 4201 Wilson Boulevard, Room 935, Arlington, VA 22230; or contact the division by telephone, 800-437-7408, or by e-mail, intpubs@nsf.gov. Information is also available on the INT home page, http://www.nsf.gov/sbe/int/start.htm.

**International Research Fellow Awards (worldwide)**
**703-292-8711**

**Africa, Near East, and South Asia**
**703-292-8707**

**The Americas**
**703-292-8706**

**Central and Eastern Europe**
**703-292-8703**

**East Asia and the Pacific**
**703-292-8704**

**Western Europe**
**703-292-8702**