NATIONAL SCIENCE FOUNDATION

FY 2009 Budget Request to Congress

February 4, 2008

About the Cover:

In the spring of 2008, scientists and engineers will complete construction of the Large Hadron Collider, a 27-kilometer underground ring located at the European Centre for Nuclear Research (CERN) in Geneva, Switzerland. The LHC will be the premier facility for research in elementary particle physics and the world's most powerful high energy physics accelerator. Research at the LHC is expected to lead to a new understanding of science at the smallest scales ever investigated. Scientists predict that its very-high-energy proton collisions will yield extraordinary discoveries about the nature of the physical universe. The LHC experiments could reveal the origins of mass, shed light on dark matter, uncover hidden symmetries of the universe, and possibly find extra dimensions of space.

Because of its unprecedented size and complexity, the LHC project required a new paradigm of international collaboration, as it involves close to 10,000 scientists and engineers from more than 50 nations. The United States, with NSF and the Department of Energy support, is involved in the construction of two particle detectors, A Toroidal LHC Apparatus (ATLAS) and the Compact Muon Solenoid (CMS). Supported by NSF, researchers in over 40 U.S. universities are involved with the LHC project. The U.S. LHC collaborations are playing an important role in the development of the new so-called GRID-based cyber infrastructure being used by particle physics and other sciences requiring massive computational, networking, and storage resources. The GRID technology will enable the participation of U.S. faculty and students in the transformational discovery potential of the LHC.

Shown on the cover is the ATLAS Barrel Toroid Magnet, so enormous that a human is dwarfed at its center.

Image courtesy of CERN.

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Budget Request

The National Science Foundation proposes a FY 2009 investment of \$6.85 billion to advance the frontiers of research and education in science and engineering. The Budget Request includes an increase of \$822 million (14 percent) over the FY 2008 level. These NSF investments in new knowledge and talent development are vital to advance the frontiers of discovery and to ensure that America remains a global leader in science and technology.

The Administration and Congress have conveyed their clear determination to build on America's history of success in leading-edge discovery and innovation through increased federal investments in research and education as evidenced by the President's American Competitiveness Initiative (ACI) and the America COMPETES Act of 2007.

Developments worldwide are driving a new innovation imperative. Knowledge-intensive industries, both in services and manufacturing, are reshaping the global economy. As was noted in *Science and Engineering Indicators 2008*, high-technology manufacturing worldwide has increased its share of total manufacturing output by 50 percent over the past 20 years. Similarly, knowledge-intensive services (which include business, communication, and financial services) have grown roughly 40 percent faster than other services since the mid 1990s. [1]

NSF Funding by Account

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Research and Related Activities[1/]	\$4,758.44	\$4,821.47	\$5,593.99	\$772.52	16.0%
Education and Human Resources	695.65	725.60	790.41	64.81	8.9%
Major Research Equipment and Facilities Construction	166.21	220.74	147.51	-73.23	-33.2%
Agency Operations and Award Management	248.49	281.79	305.06	23.27	8.3%
National Science Board	3.65	3.97	4.03	0.06	1.5%
Office of Inspector General	11.92	11.43	13.10	1.67	14.6%
Rescission required under P.L. 110-161[2/]	-	-33.00	-	33.00	-100.0%
Total, NSF	\$5,884.37	\$6,032.00	\$6,854.10	\$822.10	13.6%

Totals may not add due to rounding.

[1/] Funding for EPSCoR was transferred to the Research and Related Activities appropriation in FY 2008. It was previously funded within the Education and Human Resources appropriation. EPSCoR is included here in Research and Related Activities for all years for comparability.

[2/] P.L. 110-161 requires the rescission of \$33.0 million from prior year unobligated balances.

[1] National Science Board. 2008. *Science and Engineering Indicators 2008*. Two volumes. Arlington, VA: National Science Foundation (volume 1, NSB 08-01; volume 2, NSB 08-01A). P. O-9. www.nsf.gov/statistics/indicators/

Continued excellence in fundamental research and education is important to sustain innovation and sharpen the Nation's competitive edge. This request upholds the commitment outlined in the ACI to double investments in three ACI agencies (NSF, the Department of Energy's Office of Science, and the Department of Commerce's National Institute of Standards and Technology) over 10 years.

NSF's task is to keep scientists and engineers focused on the furthest frontier, to recognize and nurture emerging fields, to prepare the next generation of scientific talent and leaders, to provide world-class facilities to advance research, and to ensure that all Americans gain an understanding of what science and technology have to offer. The Nation's ability to innovate and compete, its strength and versatility, depend in part on continued success in achieving these goals.

NSF has identified strategies for FY 2009 to address these challenges. The NSF portfolio aims to maintain powerful momentum across all fields of science and engineering, support potentially transformative research, build a world-class science and engineering workforce, and perform effectively and responsibly, with the highest standards of accountability.

Why Frontier Research Matters

Globalization has amplified the worldwide competition for ideas, for science and engineering talent, and for leadership in turning new knowledge into real world applications. For the last half century, the U.S. has held the commanding position in all three areas. Now, other nations are implementing new policies and stepping up investments in research and training new talent. These global initiatives pose new challenges for America's innovation enterprise.

The current pace of discovery is so rapid that identifying potentially transformative ideas and concepts is essential if our aim is to remain at the forefront of scientific research and technological innovation. The Nation's innovation system, key to economic growth and increasing productivity, thrives on the continual stream of fresh ideas that fundamental research provides, and performs at its best when diverse talent is engaged and poised to generate the sophisticated solutions necessary to meet the complex and challenging questions of our times.

America has always been a valued partner in the global arena. The international character of today's science and engineering puts a premium on our continued leadership in building collaborations, contributing to the world's knowledge and crafting solutions to global problems, as well as learning from discoveries made elsewhere. These changing global circumstances demand that we take steps to demonstrate our continued leadership.

Although U.S. expenditures for R&D (estimated at a record $340 billion in 2006) remain the highest of any nation, new challenges are on the horizon.

U.S. exports of high-technology products have eroded, raising concerns about the Nation's decades-long comparative advantage in these products. The U.S. trade balance in high-technology products shifted from surplus to deficit beginning in 2002. Rapidly increasing exports of information and communications products, particularly from China and Malaysia, account for this deficit.[2]

[2] Indicators 2008, Pp. O-10, O-19.

NSF plays an important role in addressing these challenges. Working at the leading-edge of the U.S. science and engineering enterprise, NSF provides nearly half of the federal investment in non-medical basic research at academic institutions and supports science and mathematics education at all levels.

Research that Benefits the Nation

NSF investments in research and education have returned exceptional dividends to the American people. At the same time, new opportunities to make progress in meeting pressing national needs in energy, health, security, and environment, as well as to resolve longstanding dilemmas of global scope are now more plentiful than ever before. Just this past year, researchers funded by NSF reported significant results and launched new initiatives that will keep benefits flowing to the American people and the world. Examples include:

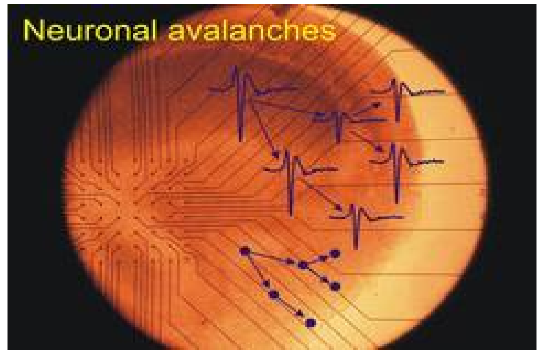
► **Wireless Power Transfer:** Researchers from the Massachusetts Institute of Technology have experimentally demonstrated an important step for the wireless transfer of power that could be used for everyday cordless devices, with the potential to revolutionize the wireless industry and eliminate the need for batteries. To produce "witricity," the researchers coupled two electromagnetic resonators, creating a highly efficient power transfer. Their design consists of two self-resonant copper coils, a sending unit, and a receiving unit. The sending unit is attached to the power source and surrounds itself with a non-radiative magnetic field. The receiving unit resonates with the field, producing a strong connection between the two units. The team crafted the strongly coupled system through this interaction, which functioned even when the two objects were separated by a large distance.

Researchers demonstrated that power levels high enough to run a laptop can be transferred over the distance of a room even with objects obstructing the sending and receiving units. *Credit: © 2007 Jupiter Images Corporation.*

Credit: Jupiter Images

► **An Integrated River Science:** Investigators are breaking new ground in quantifying how vegetation interacts with flow rates and river channel configuration during flood events. By observing, quantifying and modeling how woody debris reshapes river channels, the researchers gained guidance for a river restoration strategy that balances the benefits of restoration to the aquatic system with the benefits of reducing flood potential. These studies by an NSF-supported team from the Massachusetts Institute of Technology, Colorado State University, and Stanford University give engineers, ecologists, and water resource managers powerful tools for mitigating environmental degradation and coping with extreme floods in river systems around the world.

► **Modeling Brain Activity:** How does the brain recognize a face, or remember the route to go home? These operations are performed not by single brain cells but by networks of neurons. Researchers at Indiana University demonstrated that activity could travel through neural networks in the form of cascades, or "neuronal avalanches." When plotted on a graph these avalanches form a straight line, indicating a "power law" function. Many complex systems, including earthquakes, forest fires, nuclear chain reactions, and avalanches in sand piles have been found to obey power laws. Since simulations suggest that neuronal avalanches can simultaneously optimize information transmission and information storage, this new knowledge could lead to novel design principles for artificial neural networks and may eventually suggest approaches to improving information processing in human brains.



This shows a brain segment on top of a microelectrode array. Superimposed in the upper right are voltage signals produced by activity in groups of brain cells. These signals are connected by arrows to represent a neuronal avalanche. Neuronal avalanches can also be modeled as chain reactions, similar to those seen in nuclear fission. This is symbolized by the circles connected with arrows in the lower right. *Credit: Dr. John M. Beggs, Indiana University, Bloomington.*

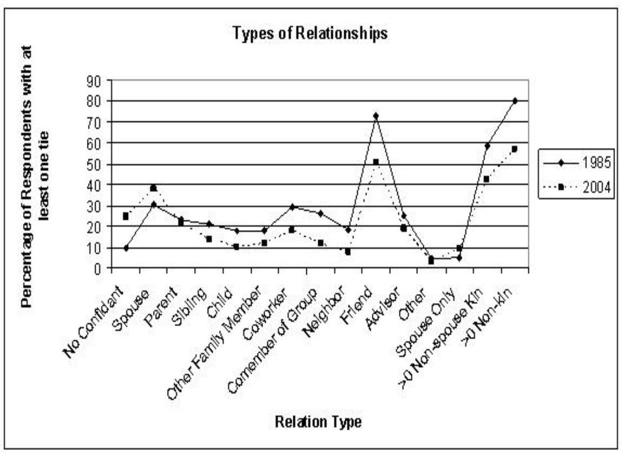
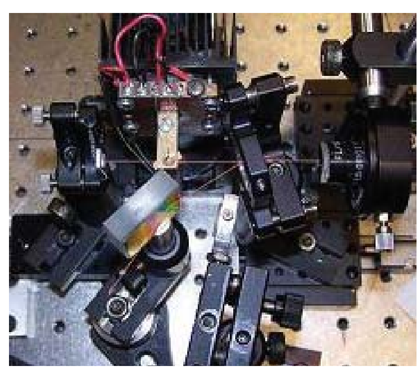


Figure shows the decrease in percentage of respondents with close social tie, by relation type, from 1985 to 2004. *Credit: Lynn Smith-Lovin, Duke University.*

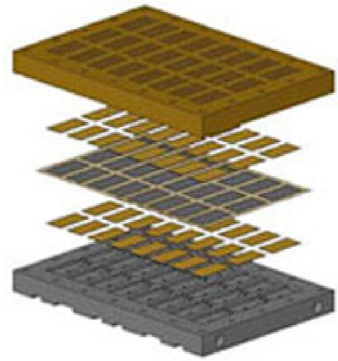
► **Social Networks in the U.S. are Shrinking:** Americans' circles of confidants have shrunk dramatically in the past two decades. The percentage of people who say they have no one with whom to discuss important matters has tripled, according to an NSF-funded study by sociologists at Duke University and the University of Arizona. This change could signal problems for our society. A close network of connections to other people creates a safety net for individuals in times of personal trouble. Having at least one connection can affect both physical and mental health. These ties are important for the community too because they often lead to civic engagement and local political action. The survey found that the number of both family and non-family confidants dropped, with the loss greatest in non-family connections.

► **Infrared Laser System: Increased Screening Sensitivity:** Researchers at the University of Alabama at Birmingham have developed a powerful system combining three types of lasers that could detect a wide range of substances in complex mixtures, including detecting trace gases at the parts per trillion level. Designed to detect and identify many types of organic molecules, the system combines high power, low noise, and coverage of the infrared spectrum that matches a large library of molecular energies. This "optical nose," developed with an NSF Major Research Instrumentation grant, could detect the presence of oil for drilling, pollutants in the atmosphere, harmful chemical or biological substances, or signs of the early stages of diseases.



The heart of the Optical Nose is a single-frequency, high-power, widely tunable Cr^{2+}:ZnSe laser. *Credit: Sergey B. Mirov, University of Alabama at Birmingham.*

► **From Discovery to Success: Polymer Membrane for Fuel Cells:** Giner, Inc. of Newton, Mass., and its subsidiary, Giner Electrochemical Systems, LLC, recipient of four NSF Small Business Innovation Research awards since 1999, were awarded a patent on a process to modify specialized polymer membranes to create compact membrane electrode structures for segmented fuel cells with higher voltages than single cells. The improvements may enable applications in electrolyzers (which convert water into hydrogen and oxygen gas), the detection and treatment of waterborne toxins, miniature sensors, industrial electro-synthesis, and other technologies that employ polymer membranes. A second patent is pending on the material itself. NSF has also provided grants to Giner for lightweight bipolar plates for fuel cells and a continuous monitor for total sulfur in natural gas.



A diagram of an array of Giner's modified polymer membrane fuel cells. *Credit: Robert MacDonald, Giner, Inc.*

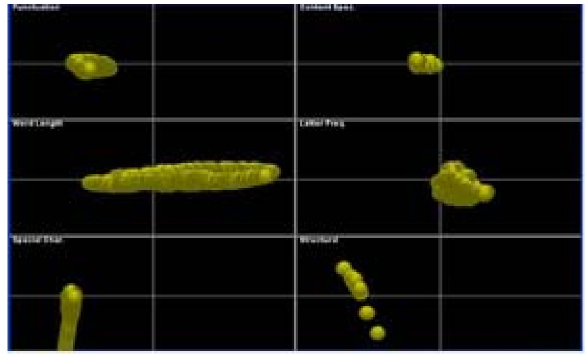
IGERT trainee Brian Schulkin shows his invention, the Mini-Z. *Credit: Rensselaer/Kris Qua.*

► **Young Inventor's Research Transforms the Marketplace:** Brian Schulkin, a participant in the NSF-funded Integrative Graduate Education and Research Traineeship program at Rensselaer Polytechnic Institute, won the first-ever Lemelson-Rensselaer $30,000 student prize. Schulkin invented an ultralight, hand-held terahertz spectrometer that has applications in medical, aerospace, security, and other fields. Terahertz rays, or "t-rays" are based on the part of the electromagnetic spectrum that is defined by frequencies from 0.1 to 10 terahertz – just between infrared light and microwave radiation. Though they can pass through clothing, wood, plastic, and other materials, t-rays are not harmful to health in the way that x-rays are. Until now, a major challenge has been the size and weight of t-ray devices. Schulkin successfully developed a system approximately the size of a laptop computer, dubbed the mini-Z. The mini-Z has already been used to detect cracks in space shuttle foam, image tumors in breast tissue, and spot counterfeit watermarks on paper currency.

► **World's Smallest Radio:** Harnessing the unique electrical and mechanical properties of carbon nanotubes, researchers have crafted a working radio from a single nanotube that is 10,000 times thinner than the width of a single human hair. Fixed to an electrode mounted near a counter electrode, the tube successfully performed the four critical roles of a radio – antenna, tunable filter, amplifier and demodulator – to tune-in a radio signal generated in the room and play it back through an attached speaker. Tunable across a bandwidth widely used for commercial radio, the tiny device could have applications far beyond novelty, from a single receiver in a living cell to a vast array embedded in an airplane wing. The new device was developed at NSF's Center of Integrated Nanomechanical Systems at the University of California at Berkeley and the Lawrence Berkeley National Laboratory.

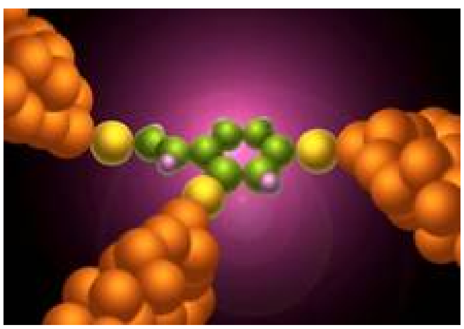
This transmission electron microscope image (with digital illustration of radio "waves") shows a single carbon nanotube protruding from an electrode. *Credit: Zettl Research Group, University of California at Berkeley and the Lawrence Berkeley National Laboratory.*

► **Research Helps Fight the (Cyber) War on Terror:** The speed, ubiquity, and potential anonymity of Internet media – email, Web sites, and Internet forums – make them ideal communication channels for militant groups and terrorist organizations. Analyzing content has become increasingly important to the intelligence agencies that monitor these groups. Funded by NSF, researchers at the Artificial Intelligence Lab at the University of Arizona have developed the "Dark Web" project to systematically collect and analyze terrorist-generated content online using advanced analysis techniques. The Dark Web collection, which contains more than 2,000 international terrorist sites and 50 million documents, has become a major research testbed for understanding propaganda, ideology, and operations of terrorist groups.



Writeprint visualization of an extremist forum author. Six unique online writing features are shown (from top to bottom, left-to-right): punctuation, word length, special character, content feature, letter frequency, and structural feature. Each dot represents a text segment in the author's online messages. Like a fingerprint, every author has a distinct "writeprint." *Credit: © Arizona Board of Regents for The University of AZ. Artificial Intelligence Lab, Dr. Hsinchun Chen, Director.*

► **From Molecules to Computers: Theory Finds a Switch:** Theoretical physicists at the University of Arizona have developed a fundamental theory of how a current of electrons flows through a single organic molecule. Based on fundamental physical principles, the theory also predicts a way to control a current through the molecule. The results could be used to design an electric switch that operates on fundamentally different principles from modern transistors at the heart of virtually all electronic technology. Because these switches are the size of a single molecule, they provide a way to overcome the fundamental problems of power dissipation and environmental sensitivity that limit the continued rate of device miniaturization.



This conception visualizes how molecular transistors might work. A sulfonated vinyl benzene molecule lies at the core. The colors code the carbon (green), hydrogen (purple), sulfur (yellow), and gold (gold) atoms. *Credit: Charles A. Stafford, University of Arizona.*

► **Cyber Corps Partnerships at Mississippi State:** Since 2002, Mississippi State University (MSU) has accomplished a 100 percent placement rate for its NSF Scholarship for Service (SFS) students. With support from an NSF SFS capacity building grant, MSU has partnered with Jackson State University (JSU), an historically black college or university, to assist them in developing an information assurance program. Through this assistance, JSU now has its own computer security class and computer forensics class patterned after those taught at MSU. In addition, JSU partners with MSU in the production of SFS students and has placed four students in government service from this partnership. Also with SFS capacity building support, MSU brought

Washington DC high school students participating in a cyber security training workshop at Mississippi State University. *Credit: Rayford Vaughn.*

minority high school students from Washington, D.C. to MSU for training in computer security. Another SFS project supported the enhancement of MSU's digital forensics laboratory, which led to securing a major grant from the Department of Justice to train more than 1,200 law enforcement officers in cyber-crime techniques.

Budget Highlights

Cross-Foundation Investments. The FY 2009 Request includes four major cross-foundation investments that aim to have a transformative impact across science and engineering, especially in such areas of national priority as manufacturing, computing, energy, cybersecurity, sensors, and materials.

- **Cyber-enabled Discovery and Innovation (CDI),** initiated in FY 2008, increases to $100.0 million (from $47.9 million) in FY 2009 to advance science and engineering along fundamentally new pathways opened by computational capabilities. FY 2009 investments include three specific foci: From Data to Knowledge, Understanding System Complexity, and Virtual Organizations.
- **Science and Engineering Beyond Moore's Law (SEBML)** aims to position the U.S. at the forefront of communications and computation capability beyond the physical and conceptual limitations of current systems. This $20.0 million, NSF-wide effort addresses the reality that in 10 to 20 years, current silicon technology will reach the limits of Moore's Law – the empirical observation that computing power doubles roughly every 18 months. Activities in FY 2009 will encourage transformational activities as well as creating partnering opportunities with the private sector and national laboratories to accelerate innovation.
- **Adaptive Systems Technology (AST)** focuses on generating creative pathways and natural interfaces between human and physical systems that will revolutionize the development of novel adaptive systems. This investment of $15.0 million in FY 2009 is motivated by the potential of new and transformational neuroscience discoveries to improve a wide range of systems and capabilities. AST is essential to advances in highly-innovative adaptive control systems, hybrid computer architectures, improved electronic PDAs, and computer-based, self-paced, learning and training tools.
- **Dynamics of Water Processes in the Environment (WATER)** is a $10.0 million, NSF-wide investment that aims to increase fundamental understanding of the Earth's freshwater systems and provide the scientific basis for decision-making about water resources. Major efforts in FY 2009 include fundamental research on the complex processes and feedbacks that affect the vulnerability and resilience of freshwater systems to climate and environmental change. This will help to define frontier research opportunities, delineate NSF's role in this area, and advance activities in foundational water systems research.

Support for Research Grants. Strong, sustained support for individual investigator and small group activities remains a priority for investments across the Foundation. With the 16 percent growth in Research and Related Activities, NSF anticipates supporting an additional 1,370 research grants. This will help to increase the funding rate to 23 percent from 21 percent, especially for unsolicited grants that potentially advance the frontiers of learning and discovery.

New Faculty and Young Investigators. Both the ACI and America COMPETES underscore the need to strengthen the Nation's science and engineering workforce, placing special emphasis on improving opportunities for scientists and engineers at the beginning of their careers. In keeping with this, CAREER – NSF's flagship program for young faculty – increases by over $14.0 million to $181.9 million. Other activities that traditionally involve young faculty – the Research Experiences for Undergraduates Program (REU) and Research in Undergraduate Institutions Program (RUI) – also increase.

Graduate Research Fellowships (GRF). GRF is widely recognized as a unique fellowship grant program because it supports the broad array of science and engineering disciplines across all fields as well as international research activity. Funding for GRF in FY 2009 increases by $28.6 million (nearly 30 percent) to $124.8 million. This will support an estimated 3,075 fellows, an increase of 700 over the FY 2008 level. The GRF program recognizes the growing significance of the changing global environment for future scientists and engineers and is bringing more international emphasis and increasing opportunities for students to expand their knowledge of research and education in other nations and international issues affecting STEM careers.

Science and Technology Centers (STC). The FY 2009 Request includes $15.0 million for a competition to add five to seven new Science and Technology Centers. The STC Program advances discovery and innovation in science and engineering through the integration of cutting-edge research, excellence in education, targeted knowledge transfer, and development of a diverse workforce. Partnerships established by the STC Program go beyond the NSF and academia to the active participation of industry and national laboratories in research projects, the transfer of technology to appropriate industries, the application of patents derived from the work of the STCs, and the launching of spin-off companies.

Cybersecurity. The FY 2009 Request includes $116.9 million for cybersecurity research and education, with $30.0 million specifically devoted respectively to research in usability ($10.0 million); theoretical foundations ($10.0 million); and privacy ($10.0 million) to support the Comprehensive National Cybersecurity Initiative. These investments in cybersecurity and information security and privacy will produce research results that allow society to more fully exploit the potential benefits of an increasingly networked world. In addition, the Scholarship for Service program, which funds scholarships to build a cadre of federal professionals with skills required to protect the Nation's critical information infrastructure, increases by 30 percent to $15.0 million.

International Science and Engineering. Funding for the Office of International Science and Engineering increases by nearly 15 percent to $47.4 million. A major focus in FY 2009 is the Partnerships for International Research and Education (PIRE) program, which increases by $3.0 million to $15.0 million. This program funds innovative, international collaborative research projects that link U.S. institutions and researchers at all career levels with premier international collaborators to work at the most promising frontiers of new knowledge.

Oceans Research. The FY 2009 Request provides continued strong support for a range of activities to ensure a clean, healthy, and stable ocean environment. $17.0 million is included for activities to support the interagency Ocean Research Priorities Plan. Investments in facilities for oceans research also increase significantly, with an increase of $21.8 million for the Integrated Ocean Drilling Program and the Academic Research Fleet.

Polar Facilities and Logistics. NSF's investments in the facilities and infrastructure needed to support polar research increase by $30.1 million. This includes increases for energy efficiency and fuel conservation and major investments needed to ensure resupply capabilities for research facilities in the Antarctic. Also of note, NSF funding for U.S. Coast Guard (USCG) polar icebreakers decreases by $3.0 million, as beginning in FY 2009, NSF will no longer provide funds for maintaining the USCG's *Polar Star* in caretaker status.

Major Research Equipment and Facilities Construction (MREFC). Total MREFC funding decreases by $73.2 million (33 percent) in FY 2009. Support continues for three ongoing projects (the Atacama Large Millimeter Array, the IceCube Neutrino Observatory, and the Advanced Laser Interferometer Gravitational Wave Observatory). Also included is $2.5 million for design activities for the Advanced Technology Solar Telescope. Three projects (the Alaska Region Research Vessel, the National Ecological Observatory Network, and the Ocean Observatories Initiative) are not slated for additional MREFC funding in FY 2009, as each is currently completing design activities.

Enriching the Education of STEM Teachers. In FY 2009, a major focus of activities in NSF's Education and Human Resources (EHR) Directorate is Enriching the Education of Science, Technology, Engineering, and Mathematics Teachers (STEM). Major activities associated with this focus include the Math and Science Partnership program (up $2.5 million to $51.0 million) and the Robert Noyce Scholarship Program (up $800,000 to $11.6 million).

Promoting Learning through Research and Evaluation. The EHR Directorate is also increasing support for research and evaluation efforts in STEM education. Major efforts in FY 2009 include a $3.0 million increase to $10.0 million for Project and Program Evaluation and an $8.5 million increase to $108.5 million for Discovery Research K-12, which supports applied research and innovation aimed at improving STEM education at the K-12 level.

Broadening Participation. NSF remains a leader in efforts to broaden participation in science and engineering. This includes efforts to reach all states and regions, notably the Experimental Program to Stimulate Competitive Research (EPSCoR), which increases to $113.5 million in FY 2009. Efforts that focus on underrepresented groups also increase; examples include Alliances for Graduate Education and Professoriate (AGEP), the Historically Black Colleges and Universities-Undergraduate Program (HBCU-UP), the Louis Stokes Alliances for Minority Participation (LSAMP), and Centers of Research Excellence in Science and Technology (CREST). NSF has also made broadening participation a priority for program management and oversight, as is captured in the Stewardship goal for broadening participation presented in the Performance Information chapter.

Interagency R&D Priorities. NSF plays a significant role in several interagency R&D priorities including the Networking and Information Technology R&D (NITRD) program, the National Nanotechnology Initiative (NNI), the U.S. Climate Change Science Program (CCSP), the Climate Change Technology Program (CCTP), and Homeland Security.

INTERAGENCY R&D PRIORITIES
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
National Nanotechnology Initiative	$388.69	$388.69	$396.79	$8.10	2.1%
Climate Change Science Program	206.63	205.25	220.60	15.35	7.5%
Climate Change Technology Program	21.00	21.00	23.50	2.50	11.9%
Networking and Information Technology R&D	908.45	931.48	1,090.25	158.77	17.0%
Homeland Security	388.76	368.41	379.17	10.76	2.9%

The Foundation will continue as a major participant in each of these areas in FY 2009, with increases for NNI, NITRD, and CCSP. Additional information on NITRD, NNI, and CCSP can be found in the NSF-wide Investments section. For Homeland Security, additional information is available in the Summary Tables and Charts section.

Stewardship. The investments that support NSF's Stewardship goal – support excellence in science and engineering research and education through a capable and responsive organization – remain a priority in FY 2009, increasing by 13 percent to $404.3 million. The Request increases the NSF workforce by 50 staff to manage the growing and increasingly complex workload being experienced throughout the Foundation. Investments in information technology (IT) increase by 32 percent to $82.0 million, with emphasis on efforts to increase efficiency, productivity, and transparency in NSF's business processes. In this request, NSF's IT portfolio is realigned to tie funding for mission-related activities more directly to NSF's programs.

Delivering Results

NSF's FY 2009 Budget Request incorporates the Research and Development Investment Criteria outlined in the President's Management Agenda. This section describes NSF's approach to ensuring that its investments address Relevance, Quality, and Performance. More specific information on the criteria is integrated throughout this document in discussions of investments by each of NSF's directorates and major program offices.

The nature of NSF's programming gives the agency an invaluable level of flexibility and agility. NSF has proven time and again that it can respond decisively and proactively to emerging opportunities and challenges. These qualities are especially valuable in maintaining a dynamic and productive portfolio in the current funding environment. With less than six percent of the agency's budget spent on internal operations – the remaining 94 percent supports other organizations working at the frontiers of learning and discovery – NSF also maintains a high level of efficiency.

► **Relevance:** R&D programs must be able to articulate *why* this investment is important, relevant, and appropriate.

NSF is the only federal agency with a mandate to strengthen the health and vitality of U.S. science and engineering and support fundamental research and education in all scientific and engineering disciplines. NSF-sponsored activities result in new knowledge and technologies and educate a world class workforce of scientists, engineers, mathematicians, educators, and other technically trained professionals. Investment decisions are guided by the agency's strategic goals, Administration initiatives articulated by the Office of Science and Technology Policy, and national priorities, as outlined in the ACI and America COMPETES.

Although NSF investments account for only four percent of total federal funding for research and development, the agency provides 45 percent of federal support to academic institutions for non-medical basic research. NSF investments are especially vital in non-medical fields and disciplines. For over two decades, NSF has been a principal source of federal support for basic research at colleges and universities in such areas as computer science, mathematics, the physical sciences, the social sciences, the environmental sciences, engineering, and non-medical areas of the life sciences. Furthermore, while NSF does not directly support medical research, its investments benefit the medical sciences and related industries, leading to advances in diagnosis, regenerative medicine, implants, assistive devices, drug delivery, and the design and processing of pharmaceuticals.

The NSF Strategic Plan for FY 2006-2011 acknowledges and responds to the changing context that is transforming science and education research and education today. Researchers operate in an increasingly complex environment, in which science and engineering cross the boundaries of disciplines, organizations, and nations. The frontier changes quickly, and discovery requires ever-more-sophisticated skills and methods, as well as technology and instrumentation. Global competition for technical workers and science and education professionals has intensified, and so have the skills expected in today's changing workplace. Leadership and excellence in discovery, innovation, and learning are the most effective means to meet and surpass these new challenges. The Plan establishes a framework for investment strategies for research and education that directly addresses these issues.

► **Quality:** R&D programs must justify *how* funds will be allocated to ensure quality R&D.

NSF leads federal agencies in funding research and education activities based on competitive merit review, with nearly 90 percent of research and education funding going to awards selected through a competitive merit review process. In FY 2007, the last year for which complete data exist, NSF awarded nearly 11,500 new grants from roughly 45,000 competitive proposals.

All proposals for research and education projects are evaluated using two criteria: the *intellectual merit* of the proposed activity and its *broader impacts*, ranging from effects on teaching, training, and learning to improvements in cyber security. Reviewers also consider transformative potential and how well the proposed activity fosters the integration of research and education and broadens opportunities to include a diversity of participants, particularly from underrepresented groups.

Further, to ensure the highest quality in processing and recommending proposals for awards, NSF also convenes Committees of Visitors, composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. In addition, NSF directorates also utilize Advisory Committees to offer recommendations on such issues as: the mission, programs, and goals that can best serve the scientific community; how to promote quality graduate and undergraduate education; and priority investment areas for NSF-funded research.

Perhaps the most dramatic indicator of the level of competition for NSF funding is the quality of the proposals that go unfunded every year. In FY 2007, for example, proposals totaling $1.8 billion were declined due to funding constraints even though they were rated as highly as the proposals that received funding. These declined proposals represent a rich portfolio of highly regarded yet unfunded opportunities to advance research and education.

► **Performance:** R&D programs must be able to monitor and document *how well* the investment is performing.

Strategic investments intended to achieve long-term outcomes are the target of performance assessments at NSF. Specific measures of organizational effectiveness relate to the internal practices, operations, and processes that support the NSF mission. Historically, NSF has relied upon external committees of experts to evaluate the long-term outcomes from research and education. This is appropriate given the broad scope of science and engineering covered by NSF, and the critical and extensive use of merit review for selecting new awards. Over the past several years, these external evaluations have provided integral information for the assessments conducted using the Program Assessment Rating Tool (PART).

External Evaluations. The NSF Advisory Committee for GPRA Performance Assessment (AC/GPA) conducts an annual assessment of NSF's performance with respect to the achievement of the agency's three program-focused strategic goals. In its FY 2007 report, the AC/GPA stated the following:

> The Committee was unanimous in its conclusion that NSF has demonstrated "Significant Achievement" for the strategic goals of Discovery, Learning, and Research Infrastructure. The Committee has based its opinion of "Significant Achievement" not only upon the quality, quantity, and outcomes of NSF-furnished highlights but also upon the overall performance across the agency as determined from other reports made available for review. From novel discoveries in the basic sciences and engineering to educational advancements across the Science, Technology, Engineering and Mathematics (STEM) disciplines, NSF has demonstrated continued commitment to its basic goals of pursuing the highest quality research, in innovative and transformative ways, while broadening the participation in science and engineering of people from all parts of society.

Stewardship Goal. To gauge progress under the Stewardship goal, NSF established eight performance areas for 2007 focusing on internal and customer-oriented priorities that emphasize effective and efficient management practices. NSF was fully successful in seven of the eight areas for FY 2007, with partial success in the remaining area (management of large facilities). These results were presented and discussed at the November 2007 meeting of the NSF Advisory Committee for Business and Operations and are discussed further in the Performance Information chapter of this Request.

Program Assessment Rating Tool. PART is an important component of NSF's performance activities. PART performance measures and action plans have provided valuable tools for program assessment and for improving program performance and management. To date, OMB has completed more than 1,000 PART assessments, representing 98% of all Federal programs; of those, only 18 percent received the highest rating of Effective. All NSF programs assessed to date received an Effective rating, with one additional assessment slated for completion in FY 2008.

SUMMARY TABLES

National Science Foundation
FY 2009 Budget Request to Congress
Summary of Major Changes by Account

(Dollars in Millions)

NSF FY 2008 Estimate	**$6,065**

Research and Related Activities

Biological Sciences **+63**

Funding increases for disciplinary and interdisciplinary research across all core programs. Support is provided for the new BIO investment, Life in Transition as well as for the NSF-wide investments in Adaptive Systems Technology (AST) and Dynamics of Water Processes in the Environment. Continued support is provided for the Plant Genome Research Program. The Center for Research at the Interface of the Mathematical and Biological Sciences will be established and enhanced support will be directed to the Center for Environmental Implications of Nanotechnology. BIO is requesting a realignment of two activities in FY 2009. The first will move Plant Genome Research as a new program line under the Integrative Organismal Systems (IOS) subactivity. The second move will transfer management and oversight of NEON to the Emerging Frontiers (EF) subactivity.

Computer and Information Science and Engineering **+104**

Investments increase in core and emerging areas that emphasize transformative work including the exploration of revolutionary computational models, languages, and tools, and hardware and software architectures; transformative research on trustworthy software and networked systems; and exploration of human-centered computing and information and intelligent systems that promise value to a diverse range of individuals and to society at large. CISE will invest in cybersecurity research and education, with emphases on research in usability, theoretical foundations, and privacy. Enhanced investment in CDI will allow for multidisciplinary projects that emphasize the application of computational thinking and algorithmic insights across all areas supported by NSF. Research in AST will support new directions in which the robustness and adaptive capability of biological organisms inform the problems and approaches taken within CISE research. Through investments in SEBML, CISE will explore new computing paradigms, including bio-inspired and quantum computing.

Engineering **+122**

ENG's core represents a broad and synergistic convergence of fields, disciplines, and frontier opportunities. Increases in FY 2009 focus on multidisciplinary, cutting-edge, and high-impact research. ENG will also support simulation-based engineering and science, a crucial and far-reaching capability enabled by cyberinfrastructure. As cyber-enabled discovery advances, so too must the use of it, such as multiscale modeling, sensor systems, simulation, and integration of large data sets which will allow for predictive decision-making. ENG research in nanomanufacturing, photonics, and micro- and nanoelectronics will result in the new materials and devices—such as microelectronics that exploit properties at the quantum level—required to realize computing capacity beyond the limits suggested by Moore's Law. ENG will support the NSF-wide AST investment, particularly in the area of neural engineering. This field promises to develop techniques and systems that will enable new understanding of the brain, nervous system, and other crucial processes in the body.

National Science Foundation
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(Dollars in Millions)

Geosciences	**+96**

Support increases for investments in fundamental research, particularly in areas such as innovation, understanding global and regional environmental issues, natural disasters, and improving the future quality of life. GEO will support highly meritorious proposals addressing both the near-term and long-term priorities articulated in the Ocean Research Priorities Plan. Increased funding will be directed to the NSF-wide investment in CDI and support will be provided for the new investment in Water. Enhanced support for the Academic Research Fleet will support ship operations and a number of enhancements to the academic fleet. Support will be provided for operation of EarthScope, IRIS, NCAR, Ocean Drilling activities and activities to prepare for the Ocean Observatories Initiative. Support for community instruments and databases, including the University Navstar Consortium (UNAVCO), a number of radar facilities to study processes in the upper atmosphere, and many small instruments supported for research community use will also be increased.

Mathematical and Physical Sciences	**+235**

Increased support for CDI will allow for essential research on modeling, algorithms, software, and simulation. Funding for SEBML will support interdisciplinary research leading to the development of new hardware, architectures, algorithms, and software required to address approaching physical and conceptual limits in computer processing power. Support will also begin for AST with emphasis on understanding the behavior of physical and biological systems across length and time scales, developing new instrumentation, and creating synthetic biological systems that can mimic nature. Increased funding is also requested for research at the MPS-Life Science Interface, Quantum Information Sciences, ACI Fellows Program, and CAREER. Strong support is requested for the Centers for Chemical Innovation and Materials Research Science and Engineering Centers. Within MPS facilities, modest increases for a number of observatories and labs will support the ongoing development of next generation instrumentation and enhance user programming; reduced funding will allow for planned programmatic transitions and phase outs.

Social, Behavioral and Economic Sciences	**+18**

Funding increases for core disciplinary and interdisciplinary research, especially targeting research across traditional boundaries and potentially transformative research. A major contribution to the Administration's American Competitiveness Initiative comes through enhanced support for Science of Science and Innovation Policy (SciSIP) research and associated increases to enable a full-scale pilot of a redesigned Survey of Industrial Research and Development (renamed Business Research and Development Survey) as well as pilot data collection on postdoctoral research and education activities. Expansion of SBE research in complexity and systems thinking in the human sciences includes increases for SBE's participation in CDI. SBE participation in AST involves applying and expanding what is known from cognitive and learning sciences in partnership with other directorates. Within the Learning strategic area, funding increases for the Research Experiences for Undergraduates (Sites) program.

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(Dollars in Millions)

Office of Cyberinfrastructure	**+35**
OCI extends support for the development and provision of software and services that facilitate complex S&E research including innovative approaches to the management of data collections, software that enhances the interoperability of data and tools, and robust middleware that supports distributed applications. Additional areas of emphasis include the use of in situ computation in sensor networks, virtual organizations that are built around specific complex research foci, research aimed at improving the effectiveness of collaborative digital environments, and the development of more robust approaches to fault-tolerant computing in S&E. Increased funding will support high-performance computing systems for the national open S&E research community. These leading-edge computational resources, together with advanced networking capabilities, serve to maintain NSF's TeraGrid as the world's leading high-end computing environment for open research. Support for CDI includes development and deployment of cybertools.	
Office of International Science and Engineering	**+6**
Increased support for the Partnerships for International Research and Education program will fund innovative, international collaborative research projects that link U.S. institutions and researchers at all career levels with premier international collaborators to work at the most promising frontiers of new knowledge. Funding will also enable OISE to support the NSF-wide investment in CDI by working to link research communities across international boundaries to facilitate communication and collaboration. Additional funding will support the International Research Experiences for Students and the International Research Fellowship Program.	
Office of Polar Programs	**+48**
Funds will support IPY synthesis activities to provide an integrated understanding of environmental change in the Arctic, and to advance understanding of the Antarctic system in a global context. Support will increase for climate change research and the associated observing and modeling systems, and for development of instrumentation and equipment that have the potential to transform data collection, monitoring and modeling. Funds for IceCube Neutrino Observatory research and operations will increase. OPP will continue to enhance the critical infrastructure required to conduct research in the Arctic and in Antarctica, including use of alternative energy for power generation and use of energy efficient construction materials. Support will also increase to diversify and improve U.S. Antarctic Program resupply at McMurdo and Palmer Stations. Funding will increase for safety and health program activities. Funding decreases for USCG Icebreaking, as NSF will no longer provide funds for maintaining the *Polar Star* in caretaker status.	
Integrative Activities	**+44**
Funding increases for the Major Research Instrumentation (MRI) program, allowing for enhanced support for the acquisition and development of mid-size instruments. Funding also provides for additional support in the EPSCoR program and for a new class of five to seven Science and Technology Centers.	
United States Arctic Research Commission	**+0**
Increases funding by $60,000 to support Commissioners' salaries as well as travel and administrative costs.	
Subtotal, R&RA	**+773**

National Science Foundation
FY 2009 Budget Request to Congress
Summary of Major Changes by Account

(Dollars in Millions)

Education and Human Resources	**+65**
Increased investment across EHR's five thematic priorities will provide continued national leadership in STEM research, policy and practice: Broadening Participation; Teacher Education in STEM; Furthering Public Understanding of Science; Promoting Cyber-enabled Learning Strategies; and Promoting Learning through Research and Evaluation. A significant increase will be directed to the Graduate Research Fellowship program, providing support for an additional 700 fellows. Increased funding for Discovery Research K-12 will support development of more effective tools and resources for teachers and students. Enhanced support for CREST, ADVANCE, and Research on GSE will contribute to the ongoing effort to broaden participation. Additional funds in the Scholarship for Service program will provide support for up to an additional nine cohorts of students. Enhanced funding for Project and Program Evaluation will support education research projects. Funding increases are focused on areas with demonstrated results, in keeping with the Academic Competitiveness Council framework.	
Major Research Equipment and Facilities Construction	**-73**
Funding will support ongoing construction of IceCube, ALMA, and Advanced LIGO, and will support design activities related to the ATST. No funding is requested for three ongoing projects, ARRV, NEON, and OOI, pending completion of final design reviews.	
Agency Operations and Award Management (formerly Salaries and Expenses)	**+23**
An allocation increase of 25 FTE will support achievement of NSF's Stewardship strategic goal. Continued emphasis will be placed on award oversight and management, particularly for large facilities. IT investments are realigned to tie mission-related activities more directly to NSF's programs.	
National Science Board	**+0**
A funding increase of $61,000 will be used for personnel compensation and general operating expenses.	
Office of Inspector General	**+2**
Increased funding of $1.67 million will cover higher personnel costs, the acquisition of software to make the auditing process more efficient, and the increasing costs of audits conducted by CPA firms under contract to OIG.	
Total Change, FY 2008 Estimate to FY 2009 Request	**+789**
NSF FY 2009 Budget Request to Congress	**$6,854**

Totals may not add due to rounding.

National Science Foundation
Summary Tables
FY 2009 Budget Request to Congress

(Dollars in Millions)

NSF by Account	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2009 Request change over: FY 2007 Actual Amount	FY 2007 Actual Percent	FY 2008 Estimate Amount	FY 2008 Estimate Percent
BIO	$608.54	$612.02	$675.06	$66.52	10.9%	$63.04	10.3%
CISE	526.68	534.53	638.76	112.08	21.3%	104.23	19.5%
ENG *(less SBIR/STTR)*	521.33	527.50	632.33	111.00	21.3%	104.83	19.9%
SBIR/STTR	108.67	109.37	127.00	18.33	16.9%	17.63	16.1%
GEO	745.85	752.66	848.67	102.82	13.8%	96.01	12.8%
MPS	1,150.73	1,167.31	1,402.67	251.94	21.9%	235.36	20.2%
SBE	214.54	215.13	233.48	18.94	8.8%	18.35	8.5%
OCI	182.42	185.33	220.08	37.66	20.6%	34.75	18.8%
OISE	40.36	41.34	47.44	7.08	17.6%	6.10	14.8%
OPP	438.43	442.54	490.97	52.54	12.0%	48.43	10.9%
IA	219.45	232.27	276.00	56.55	25.8%	43.73	18.8%
U.S. Arctic Research Commission	1.45	1.47	1.53	0.08	5.5%	0.06	4.1%
Research & Related Activities	**$4,758.44**	**$4,821.47**	**$5,593.99**	**$835.55**	**17.6%**	**$772.52**	**16.0%**
Education & Human Resources	**$695.65**	**$725.60**	**$790.41**	**$94.76**	**13.6%**	**$64.81**	**8.9%**
Major Research Equipment & Facilities Construction	**$166.21**	**$220.74**	**$147.51**	**-$18.70**	**-11.3%**	**-$73.23**	**-33.2%**
Agency Operations & Award Management	**$248.49**	**$281.79**	**$305.06**	**$56.57**	**22.8%**	**$23.27**	**8.3%**
National Science Board	**$3.65**	**$3.97**	**$4.03**	**$0.38**	**10.4%**	**$0.06**	**1.5%**
Office of Inspector General	**$11.92**	**$11.43**	**$13.10**	**$1.18**	**9.9%**	**$1.67**	**14.6%**
Total, NSF	**$5,884.37**	**$6,065.00**	**$6,854.10**	**$969.73**	**16.5%**	**$789.10**	**13.0%**

* Totals may not add due to rounding.

(Dollars in Millions)

NSF by Strategic Goal	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2009 Request change over: FY 2007 Actual Amount	FY 2007 Actual Percent	FY 2008 Estimate Amount	FY 2008 Estimate Percent
Discovery	$3,200.60	$3,263.83	$3,847.98	$647.38	20.2%	$584.15	17.9%
Learning	785.00	808.82	864.98	79.98	10.2%	56.16	6.9%
Research Infrastructure	1,578.70	1,633.30	1,736.85	158.15	10.0%	103.55	6.3%
Stewardship	320.07	359.05	404.29	84.21	26.3%	45.24	12.6%
Total, NSF	**$5,884.37**	**$6,065.00**	**$6,854.10**	**$969.73**	**16.5%**	**$789.10**	**13.0%**

* Totals may not add due to rounding.

National Science Foundation
By Account and Strategic Outcome Goal
FY 2009 Budget Request to Congress

(Dollars in Millions)

NSF Accounts	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request: Discovery	Learning	Research Infrastructure	Stewardship	FY 2009 Request	Change over FY 2007 Actual: Amount	Percent	Change over FY 2008 Estimate: Amount	Percent
FY 2007 Actual	**$5,884.37**		**$3,200.60**	**$785.00**	**$1,578.70**	**$320.07**					
FY 2008 Estimate		**$6,065.00**	**$3,263.83**	**$808.82**	**$1,633.30**	**$359.05**					
BIO	$608.54	$612.02	$490.66	$43.14	$133.02	$8.24	$675.06	$66.52	10.9%	$63.04	10.3%
CISE	526.68	534.53	564.70	37.60	26.50	9.96	638.76	112.08	21.3%	104.23	19.5%
ENG *(less SBIR/STTR)*	521.33	527.50	534.09	54.62	32.42	11.20	632.33	111.00	21.3%	104.83	19.9%
SBIR/STTR	108.67	109.37	127.00	-	-	-	127.00	18.33	16.9%	17.63	16.1%
GEO	745.85	752.66	464.80	30.75	342.57	10.55	848.67	102.82	13.8%	96.01	12.8%
MPS	1,150.73	1,167.31	984.91	68.07	334.06	15.63	1,402.67	251.94	21.9%	235.36	20.2%
SBE	214.54	215.13	179.33	9.43	39.87	4.85	233.48	18.94	8.8%	18.35	8.5%
OCI	182.42	185.33	27.50	4.10	185.73	2.75	220.08	37.66	20.6%	34.75	18.8%
OISE	40.36	41.34	31.57	13.25	-	2.62	47.44	7.08	17.6%	6.10	14.8%
OPP	438.43	442.54	120.69	5.58	361.14	3.56	490.97	52.54	12.0%	48.43	10.9%
IA	219.45	232.27	143.49	13.56	118.04	0.91	276.00	56.55	25.8%	43.73	18.8%
U.S. Arctic Research Commission	1.45	1.47	1.53	-	-	-	1.53	0.08	5.5%	0.06	4.1%
Research & Related Activities	**$4,758.44**	**$4,821.47**	**$3,670.27**	**$280.10**	**$1,573.35**	**$70.27**	**$5,593.99**	**$835.55**	**17.6%**	**$772.52**	**16.0%**
Education & Human Resources	**$695.65**	**$725.60**	**$177.71**	**$584.88**	**$15.99**	**$11.83**	**$790.41**	**$94.76**	**13.6%**	**$64.81**	**8.9%**
Major Research Equipment & Facilities Construction	**$166.21**	**$220.74**	-	-	**$147.51**	-	**$147.51**	**-$18.70**	**-11.3%**	**-$73.23**	**-33.2%**
Agency Operations & Award Management	**$248.49**	**$281.79**	-	-	-	**$305.06**	**$305.06**	**$56.57**	**22.8%**	**$23.27**	**8.3%**
National Science Board	**$3.65**	**$3.97**	-	-	-	**$4.03**	**$4.03**	**$0.38**	**10.4%**	**$0.06**	**1.5%**
Office of Inspector General	**$11.92**	**$11.43**	-	-	-	**$13.10**	**$13.10**	**$1.18**	**9.9%**	**$1.67**	**14.6%**
Total, National Science Foundation	**$5,884.37**	**$6,065.00**	**$3,847.98**	**$864.98**	**$1,736.85**	**$404.29**	**$6,854.10**	**$969.73**	**16.5%**	**$789.10**	**13.0%**
H-1B Visa	*$145.94*	*$100.00*					*$100.00*				
Total NSF, Including H-1B Visa	*$6,030.31*	*$6,165.00*	*$3,847.98*	*$864.98*	*$1,736.85*	*$404.29*	*$6,954.10*	*$923.79*	*15.3%*	*$789.10*	*12.8%*
Percent Increase over Prior Year, excluding H-1B Visa			**17.9%**	**6.9%**	**6.3%**	**12.6%**					

Totals may not add due to rounding.

National Science Foundation
Research Infrastructure Summary
FY 2009 Budget Request to Congress

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Academic Research Fleet	$87.95	$70.66	$83.96	$13.30	18.8%
Regional Class Research Vessels	*1.57*	*1.50*	*10.00*	8.50	566.7%
RHOV Construction (R/V Alvin Replacement)	*9.05*	*1.00*	*1.00*	-	-
R/V Langseth Construction (R/V Ewing Replacement)	*0.69*	*2.00*	-	*-2.00*	*-100.0%*
Ship Operations and Upgrades	*76.63*	*66.16*	*72.96*	*6.80*	*10.3%*
Cornell Electron Storage Ring	14.71	13.71	8.50	-5.21	-38.0%
Gemini	20.00	20.00	22.00	2.00	10.0%
EarthScope: USArray, SAFOD, PBO[1/]	11.63	17.61	26.29	8.68	49.3%
Incorporated Research Institutions for Seismology	11.77	11.75	12.20	0.45	3.8%
Integrated Ocean Drilling Pgm/ODP/SODV[2/]	36.81	39.26	47.74	8.48	21.6%
Large Hadron Collider	18.00	18.00	18.00	-	-
Laser Interferometer Gravitational Wave Observatory	33.00	29.50	28.50	-1.00	-3.4%
Major Research Equipment & Facilities Construction[/3]	189.60	260.96	200.08	-60.88	-23.3%
Major Research Instrumentation	90.00	93.90	115.00	21.10	22.5%
National Astronomy & Ionosphere Center	10.46	12.15	11.40	-0.75	-6.2%
National Center for Atmospheric Research	85.12	87.54	95.87	8.33	9.5%
National High Magnetic Field Laboratory	26.55	26.50	31.50	5.00	18.9%
National Nanofabrication Infrastructure Network (NNIN)	13.32	13.50	13.50	-	-
National Optical Astronomy Observatories	39.28	38.55	41.83	3.28	8.5%
National Radio Astronomy Observatories	47.03	44.52	49.79	5.27	11.8%
National Science Distributed Learning	18.73	16.25	16.50	0.25	1.5%
National Superconducting Cyclotron Laboratory	18.50	18.50	20.50	2.00	10.8%
Network for Earthquake Engineering Simulation	20.74	22.17	23.02	0.85	3.8%
Polar Environment, Safety & Health	5.79	5.98	6.74	0.76	12.7%
Polar Facilities and Logistics[/4]	317.46	323.54	352.25	28.71	8.9%
Research Resources[/5]	239.93	246.57	271.38	24.81	10.1%
Science and Technology Policy Institute	4.32	2.24	3.04	0.80	35.7%
Science Resource Statistics	29.71	29.55	32.57	3.02	10.2%
Shared Cyberinfrastructure Tools	176.28	158.43	185.73	27.30	17.2%
Other Facilities[/6]	12.01	11.96	18.96	7.00	58.5%
RESEARCH INFRASTRUCTURE TOTAL	**$1,578.69**	**$1,633.30**	**$1,736.85**	**$103.55**	**6.3%**

Totals may not add due to rounding.

[/1] EarthScope funding includes support provided through the R&RA account for operations and maintenance of the facility. Support provided through the MREFC account for the construction of the project, totaling $25.93 million in FY 2007, is included in the MREFC projects line.

[/2] Funding for Integrated Ocean Drilling Program (IODP) includes support for the continued phase-out of program and contract activities for the Ocean Drilling Program (ODP), predecessor to the IODP. ODP funding concludes in FY 2007, at a level of $2.11 million. This line also includes support for the operations and maintenance of the Scientific Ocean Drilling Vessel (SODV); MREFC funding for the SODV, the final year of which was FY 2007, at $42.83 million, is included on the MREFC projects line.

[/3] Funding levels for MREFC projects in this table include support for concept and development associated with these projects, initial support for operations and maintenance (both provided through the R&RA account), and implementation support provided through the MREFC account.

[/4] Polar Facilities and Logistics includes support for the operations and maintenance of the South Pole Station. Funds provided through the MREFC account for the South Pole Station Modernization (SPSM) project ($6.19 million in FY 2007 and $9.10 million in FY 2008) are included in the MREFC projects line.

[/5] Funding for Research Resources includes support for the operation of the Advanced Modular Incoherent Scatter Radar (AMISR), which is approximately $3 million per year.

[/6] Other Facilities includes support for other physics and materials research facilities, and other related costs.

National Science Foundation
Selected Cross-Cutting Programs
FY 2009 Budget Request to Congress

(Dollars in Millions)

Selected Cross-Cutting Programs		FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2009 Request change over: FY 2007 Actual Amount	Percent	FY 2008 Estimate Amount	Percent
ADVANCE	Research & Related Activities	16.58	20.85	19.54	2.96	17.9%	-1.31	-6.3%
	Education & Human Resources	0.04	0.50	1.25	1.21	3278.4%	0.75	150.0%
	Total, NSF	**$16.61**	**$21.35**	**$20.79**	**$4.18**	**25.1%**	**-$0.56**	**-2.6%**
Faculty Early Career Development - CAREER	Research & Related Activities	187.40	167.76	181.91	-5.49	-2.9%	14.15	8.4%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$187.40**	**$167.76**	**$181.91**	**-$5.49**	**-2.9%**	**$14.15**	**8.4%**
Graduate Research Fellowships - GRF	Research & Related Activities	8.14	8.06	8.06	-0.08	-1.0%	-	-
	Education & Human Resources	86.08	88.10	116.70	30.62	35.6%	28.60	32.5%
	Total, NSF	**$94.22**	**$96.16**	**$124.76**	**$30.54**	**32.4%**	**$28.60**	**29.7%**
Graduate Teaching Fellowships in K-12 Education - GK-12	Research & Related Activities	8.09	8.31	8.31	0.22	2.7%	-	-
	Education & Human Resources	44.55	47.00	49.00	4.45	10.0%	2.00	4.3%
	Total, NSF	**$52.64**	**$55.31**	**$57.31**	**$4.67**	**8.9%**	**$2.00**	**3.6%**
Integrative Graduate Education and Research Training - IGERT	Research & Related Activities	42.37	37.82	38.79	-3.58	-8.5%	0.97	2.6%
	Education & Human Resources	25.27	25.00	25.00	-0.27	-1.1%	-	-
	Total, NSF	**$67.64**	**$62.82**	**$63.79**	**-$3.85**	**-5.7%**	**$0.97**	**1.5%**
Total, Graduate Fellowships & Traineeships	Research & Related Activities	$58.60	$54.19	$55.16	-3.44	-5.9%	0.97	1.8%
	Education & Human Resources	$155.90	$160.10	$190.70	34.80	22.3%	30.60	19.1%
	Total, NSF	**$214.50**	**$214.29**	**$245.86**	**$31.36**	**14.6%**	**$31.57**	**14.7%**
Long-Term Research Sites - LTER	Research & Related Activities	24.35	24.86	25.09	0.74	3.1%	0.23	0.9%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$24.35**	**$24.86**	**$25.09**	**$0.74**	**3.1%**	**$0.23**	**0.9%**
Research Experience for Teachers - RET	Research & Related Activities	7.94	8.84	9.69	1.75	22.1%	0.85	9.6%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$7.94**	**$8.84**	**$9.69**	**$1.75**	**22.1%**	**$0.85**	**9.6%**
Research Experience for Undergraduates - REU	Research & Related Activities	63.28	57.73	61.55	-1.73	-2.7%	3.82	6.6%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$63.28**	**$57.73**	**$61.55**	**-$1.73**	**-2.7%**	**$3.82**	**6.6%**
Research Experience for Undergraduates - REU Sites Only	Research & Related Activities	48.01	41.27	44.39	-3.62	-7.5%	3.12	7.6%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$48.01**	**$41.27**	**$44.39**	**-$3.62**	**-7.5%**	**$3.12**	**7.6%**
Research Experience for Undergraduates - REU Supplements Only	Research & Related Activities	15.27	16.46	17.16	1.89	12.4%	0.70	4.3%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$15.27**	**$16.46**	**$17.16**	**$1.89**	**12.4%**	**$0.70**	**4.3%**
Research in Undergraduate Institutions - RUI	Research & Related Activities	33.03	31.53	35.23	2.20	6.7%	3.70	11.7%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$33.03**	**$31.53**	**$35.23**	**$2.20**	**6.7%**	**$3.70**	**11.7%**
Science and Technology Centers - STCs	Research & Related Activities	68.56	64.95	76.02	7.46	10.9%	11.07	17.0%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$68.56**	**$64.95**	**$76.02**	**$7.46**	**10.9%**	**$11.07**	**17.0%**

Totals may not add due to rounding.

NSF Funding Profile

Approximately half of the awards supported in a particular fiscal year are competitively reviewed in that year through NSF's merit review process. Other awards are continuations of projects that were competitively reviewed in a prior year.

Statistics for Competitive Awards: The Funding Rate is the number of competitive awards made during a year as a percentage of total proposals competitively reviewed. This indicates the probability of receiving an award when submitting proposals to NSF.

Statistics for Research Grants: Research Grants are grants limited to research projects and exclude other categories of awards that fund infrastructure-type activities, which do not require multi-year support, such as equipment and conference awards. Annualized Award Size shows the annual level of research grants provided to awardees by dividing the total dollars of each award by the number of years over which it extends. Both the average and the median annualized award size for competitively reviewed awards are shown. Average Duration is the length of the award in years.

The Quantitative Data Tables, provided under a separate tab in this submission, are based on all proposals and awards, including competitive awards, contracts, cooperative agreements, supplements, and amendments to existing grants and contracts.

NSF Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards			
Number	11,445	11,530	13,000
Funding Rate	25%	24%	26%
Statistics for Research Grants			
Number of Research Grants	7,415	7,510	8,880
Funding Rate	22%	21%	23%
Median Annualized Award Size	$109,900	$118,165	$123,575
Average Annualized Award Size	$146,270	$151,355	$158,290
Average Duration (years)	2.9	3.0	3.0

National Science Foundation
NSTC Crosscuts Summary
FY 2009 Budget Request to Congress

(Dollars in Millions)

	Climate Change Technology Program			Climate Change Science Programs Includes U.S. Global Change Research Program Climate Change Research Initiative			Networking and Information Technology Research and Development			National Nanotechnology Initiative		
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
BIO	-	-	-	$15.10	$15.10	$15.10	$83.50	$83.50	$86.15	$54.71	$55.55	$56.60
CISE	-	-	-	-	-	-	526.69	534.53	638.76	12.89	12.22	11.00
ENG	$21.00	$21.00	$23.50	1.00	1.00	1.00	11.20	19.20	28.01	137.02	137.02	140.02
GEO	-	-	-	157.72	157.72	164.72	14.56	15.56	18.98	9.65	9.65	6.33
MPS	-	-	-	6.81	5.45	6.00	73.70	70.89	73.72	169.48	169.48	178.07
SBE	-	-	-	15.50	15.48	15.48	12.47	13.47	15.05	1.67	1.67	1.67
OCI	-	-	-	-	-	-	182.42	185.33	220.08	-	-	-
OISE	-	-	-	-	-	-	-	-	-	-	-	-
OPP	-	-	-	10.50	10.50	18.30	-	-	-	-	-	-
IA	-	-	-	-	-	-	-	-	-	-	-	-
R&RA	**$21.00**	**$21.00**	**$23.50**	**$206.63**	**$205.25**	**$220.60**	**$904.54**	**$922.48**	**$1,080.75**	**$385.42**	**$385.59**	**$393.69**
EHR	-	-	-	-	-	-	**$3.91**	**$9.00**	**$9.50**	**$3.27**	**$3.10**	**$3.10**
NSF Total	**$21.00**	**$21.00**	**$23.50**	**$206.63**	**$205.25**	**$220.60**	**$908.45**	**$931.48**	**$1,090.25**	**$388.69**	**$388.69**	**$396.79**

National Science Foundation
Homeland Security Activities Summary
FY 2009 Budget Request to Congress

(Dollars in Millions)

	BIO	CISE	ENG	GEO	MPS	SBE	OPP	R&RA	EHR	AOAM	Total, NSF
FY 2007 Actual	**$21.00**	**$152.60**	**$179.17**	**$4.00**	**$8.84**	**$4.50**	**$5.36**	**$375.47**	**$11.58**	**$1.60**	**$388.65**
Protecting Critical Infrastructure & Key Assets	-	**$150.70**	**$179.17**		**$8.84**	**$4.50**	**$5.36**	**$348.57**	**$11.58**	**$1.60**	**$361.75**
Antarctic Security	-	-	-	-	-	-	4.19	4.19	-	-	4.19
Counterterrorism	-	27.00	19.97	-	-	-	-	46.97			46.97
Cybersecurity	-	93.50	3.20	-	-	-	-	96.70	-	-	96.70
Electronic Commerce	-	4.50	3.50	-	-	-	-	8.00	-	-	8.00
Emergency Planning & Response	-	25.70	26.00	-	7.84	-	-	59.54	-	-	59.54
Energy Supply Assurance	-	-	29.00	-	0.30	-	-	29.30	-	-	29.30
IT Security	-	-	-	-	-	-	1.17	1.17	0.22	1.60	2.99
Resilient Infrastructure (Risk Mgmt, Modeling, Simul)	-	-	97.50	-	0.70	4.50	-	102.70	-	-	102.70
Scholarships for Service / Cybercorps	-	-	-	-	-	-	-	-	11.36	-	11.36
Defending Against Catastrophic Threats	**$21.00**	**$1.90**	-	**$4.00**	-	-	-	**$26.90**	-	-	**$26.90**
Research to Combat Bioterrorism	21.00	1.90		4.00				26.90			26.90
Ecology of Infectious Diseases	*6.00*		-	*4.00*	-	-	-	*10.00*	-	-	*10.00*
Microbial Genome Sequencing	*15.00*	*1.90*	-	-	-	-	-	*16.90*	-	-	*16.90*
FY 2008 Estimate	**$21.00**	**$159.80**	**$159.50**	**$4.00**	**$6.74**	**$4.50**	**$1.37**	**$356.91**	**$11.50**	-	**$368.41**
Protecting Critical Infrastructure & Key Assets	-	**$159.80**	**$159.50**		**$6.74**	**$4.50**	**$1.37**	**$331.91**	**$11.50**	-	**$343.41**
Antarctic Security	-	-	-	-	-	-	1.37	1.37	-	-	1.37
Counterterrorism	-	27.00	-	-	-	-	-	27.00			27.00
Cybersecurity	-	103.50	3.20	-	0.20	-	-	106.90	-	-	106.90
Electronic Commerce	-	4.50	3.50	-	-	-	-	8.00	-	-	8.00
Emergency Planning & Response	-	24.80	26.00	-	3.46	-	-	54.26	-	-	54.26
Energy Supply Assurance	-	-	29.00	-	1.39	-	-	30.39	-	-	30.39
IT Security	-	-	-	-	-	-	-	-	-	-	-
Resilient Infrastructure (Risk Mgmt, Modeling, Simul)	-	-	97.80	-	1.69	4.50	-	103.99	-	-	103.99
Scholarships for Service / Cybercorps	-	-	-	-	-	-	-	-	11.50	-	11.50
Defending Against Catastrophic Threats	**$21.00**	-	-	**$4.00**	-	-	-	**$25.00**	-	-	**$25.00**
Research to Combat Bioterrorism	21.00			4.00				25.00			25.00
Ecology of Infectious Diseases	*6.00*	-	-	*4.00*	-	-	-	*10.00*	-	-	*10.00*
Microbial Genome Sequencing	*15.00*	-	-	-	-	-	-	*15.00*	-	-	*15.00*
Increment to FY 2009 Request	**-$6.00**	**$10.00**	**$1.00**	**-$4.00**	**$0.26**	-	-	**$1.26**	**$3.50**	**$6.00**	**$10.76**
Protecting Critical Infrastructure & Key Assets	-	**$10.00**	**$1.00**		**$0.26**		-	**$11.26**	**$3.50**	**$6.00**	**$20.76**
Antarctic Security	-	-	-	-	-	-	-		-	-	-
Counterterrorism	-	-	-	-	-	-	-		-	-	-
Cybersecurity	-	10.00	-	-	-	-	-	10.00	-	-	10.00
Electronic Commerce	-	-	-	-	-	-	-		-	-	-
Emergency Planning & Response	-	-	0.10	-	0.26	-	-	0.36	-	-	0.36
Energy Supply Assurance	-	-	0.20	-	-	-	-	0.20	-	-	0.20
IT Security	-	-		-	-	-	-		-	6.00	6.00
Resilient Infrastructure (Risk Mgmt, Modeling, Simul)	-	-	0.70	-	-	-	-	0.70	-	-	0.70
Scholarships for Service / Cybercorps	-	-	-	-	-	-	-		3.50	-	3.50
Defending Against Catastrophic Threats	**-$6.00**	-	-	**-$4.00**	-	-	-	**-$10.00**	-	-	**-$10.00**
Research to Combat Bioterrorism	-6.00			-4.00				-10.00			-10.00
Ecology of Infectious Diseases	*-6.00*	-	-	*-4.00*	-	-	-	*-10.00*	-	-	*-10.00*
Microbial Genome Sequencing	-	-	-	-	-	-	-	-	-	-	-
FY 2009 Request	**$15.00**	**$169.80**	**$160.50**	-	**$7.00**	**$4.50**	**$1.37**	**$358.17**	**$15.00**	**$6.00**	**$379.17**
Protecting Critical Infrastructure & Key Assets	-	**$169.80**	**$160.50**		**$7.00**	**$4.50**	**$1.37**	**$343.17**	**$15.00**	**$6.00**	**$364.17**
Antarctic Security	-	-	-	-	-	-	1.37	1.37	-	-	1.37
Counterterrorism	-	27.00	-	-	-	-	-	27.00			27.00
Cybersecurity	-	113.50	3.20	-	0.20	-	-	116.90	-	-	116.90
Electronic Commerce	-	4.50	3.50	-		-	-	8.00	-	-	8.00
Emergency Planning & Response	-	24.80	26.10	-	3.72	-	-	54.62	-	-	54.62
Energy Supply Assurance	-	-	29.20	-	1.39	-	-	30.59	-	-	30.59
IT Security	-	-	-	-		-	-		-	6.00	6.00
Resilient Infrastructure (Risk Mgmt, Modeling, Simul)	-	-	98.50	-	1.69	4.50	-	104.69	-	-	104.69
Scholarships for Service / Cybercorps	-	-	-	-	-	-	-		15.00	-	15.00
Defending Against Catastrophic Threats	**$15.00**	-	-	-	-	-	-	**$15.00**	-	-	**$15.00**
Research to Combat Bioterrorism	15.00							15.00			15.00
Ecology of Infectious Diseases	-	-	-	-	-	-	-	-	-	-	-
Microbial Genome Sequencing	*15.00*	-	-	-	-	-	-	*15.00*	-	-	*15.00*

NSF Programs to Broaden Participation
FY 2009 Budget Request to Congress

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2009 Request change over: FY 2007 Actual Amount	Percent	FY 2008 Estimate Amount	Percent
ADVANCE	$16.61	$21.35	$20.79	$4.18	25.1%	-$0.56	-2.6%
ADVANCE - R&RA	*16.58*	*20.85*	*19.54*	*2.96*	*17.9%*	*-1.31*	*-6.3%*
ADVANCE - EHR	*0.04*	*0.50*	*1.25*	*1.21*	*3278.4%*	*0.75*	*150.0%*
Advanced Technology Education (ATE)	50.58	51.62	51.62	1.04	2.1%	-	-
Alliances for Graduate Education and the Professoriate (AGEP)	15.27	15.35	16.75	1.48	9.7%	1.40	9.1%
Broadening Participation in Computing (BPC)	13.53	14.00	14.00	0.47	3.5%	-	-
Broadening Participation in the Biological Sciences - BIO	9.11	8.68	9.99	0.88	9.7%	1.31	15.1%
Centers of Research Excellence in Science and Technology (CREST)	18.84	25.00	30.53	11.69	62.0%	5.53	22.1%
Cyberinfrastructure Training, Education, Advancement and Mentoring (CI-TEAM)	0.31	10.00	-	-0.31	-100.0%	-10.00	-100.0%
Experimental Program to Stimulate Competitive Research (EPSCoR)	102.11	111.10	113.50	11.39	11.2%	2.40	2.2%
GEO LSAMP Linkages	1.00	1.00	1.00	-	-	-	-
Graduate Research Diversity (GRD) - ENG	-	0.75	0.75	0.75	N/A	-	-
Graduate Research Fellowships - Women in Engineering and Computer Science	8.14	8.06	8.06	-0.08	-1.0%	-	-
H-1B Nonimmigrant Petitioner Fee programs	145.94	100.00	100.00	-45.94	-31.5%	-	-
Historically-Black Colleges and Universities-Undergraduate Program (HBCU-UP)	27.86	30.00	31.00	3.14	11.3%	1.00	3.3%
Informal Science Education (ISE)	63.93	65.00	66.00	2.07	3.2%	1.00	1.5%
Integrating Research & Education in Cyberinfrastucture (IREC)	-	-	4.00	*4.00*	N/A	*4.00*	N/A
Louis Stokes Alliances for Minority Participation (LSAMP)	38.08	40.50	42.50	4.42	11.6%	2.00	4.9%
Math and Science Partnership (MSP)	45.95	48.50	51.00	5.05	11.0%	2.50	5.2%
Mentoring in Biology	6.35	5.00	5.00	-1.35	-21.2%	-	-
Minority Post-Docs	3.79	3.40	3.40	-0.39	-10.4%	-	-
BIO Minority Post-Docs	*2.86*	*2.50*	*2.50*	*-0.36*	*-12.6%*	-	-
SBE Minority Post-Docs	*0.93*	*0.90*	*0.90*	*-0.03*	*-3.6%*	-	-
Next Generation Workforce (NGW) - SBE	1.01	1.00	1.00	-0.01	-0.7%	-	-
Noyce Scholarships	10.30	10.80	11.60	1.30	12.6%	0.80	7.4%
OISE Broadening Participation		1.00	1.00	1.00	N/A	-	-
Opportunities to Enhance Diversity in the Geosciences (OEDG)	4.60	4.60	4.60	-	-	-	-
Partnerships for Innovation (PFI)	9.19	9.19	9.56	0.37	4.0%	0.37	4.0%
Partnerships for Research and Education in Materials (PREM) - MPS	3.54	5.08	9.00	5.46	154.2%	3.92	77.2%
Research in Disabilities Education (RDE)	5.37	6.00	6.50	1.13	21.0%	0.50	8.3%
Research on Gender in Science and Engineering (GSE)	9.92	10.25	11.50	1.58	15.9%	1.25	12.2%
Research Partnerships for Diversity (RPD) - MPS	0.08	2.50	2.50	2.42	3025.0%	-	-
Science, Technology, Engineering and Math Talent Expansion Program (STEP)	28.90	29.70	29.70	0.81	2.8%	-	-
Significant Opportunities in Atmospheric Research and Science (SOARS) - GEO	0.51	0.51	0.51	-	-	-	-
Tribal College Pathways - ENG	-	0.25	0.25	0.25	N/A	-	-
Tribal Colleges and Universities Program (TCUP)	10.42	12.85	13.35	2.93	28.1%	0.50	3.9%
Undergraduate Research Collaboratives (URC) - MPS	2.78	2.63	3.47	0.69	25.0%	0.84	31.9%
Subtotal, R&RA	**$182.62**	**$209.60**	**$211.13**	**$28.51**	**15.6%**	**$1.53**	**0.7%**
Subtotal, EHR	**$325.45**	**$346.07**	**$363.30**	**$37.85**	**11.6%**	**$17.23**	**5.0%**
Subtotal, H-1B Nonimmigrant Petitioner Fees	**$145.94**	**$100.00**	**$100.00**	**-$45.94**	**-31.5%**	-	-
TOTAL, NSF	**$654.01**	**$655.67**	**$674.43**	**$20.42**	**3.1%**	**$18.76**	**2.9%**

National Science Foundation
Learning Funding by Level of Education
FY 2009 Budget Request to Congress

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2009 Request change over: FY 2007 Actual		FY 2008 Estimate	
				Amount	Percent	Amount	Percent
K-12 Programs	$45.69	$48.17	$50.58	$4.90	10.7%	$2.41	5.0%
Undergraduate Programs	296.54	300.29	313.53	16.99	5.7%	13.24	4.4%
Graduate & Professional Programs	308.45	308.38	344.47	36.02	11.7%	36.09	11.7%
Multi-level and Other Programs	134.32	151.98	156.40	22.08	16.4%	4.42	2.9%
TOTAL, NSF	$785.00	$808.82	$864.98	$79.98	10.2%	$56.16	6.9%

Number of People Involved in NSF Activities

It is estimated that in FY 2009 over 211,000 people will be directly involved in NSF programs and activities, receiving salaries, stipends, or participant support. In addition, NSF programs indirectly impact many millions of people. These programs reach K-12 students, K-12 teachers, the general public, and researchers through activities including workshops; informal science activities such as museums, television, videos, and journals; outreach efforts; and dissemination of improved curriculum and teaching methods.

Number of People Involved in NSF Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	41,270	41,575	46,630
Other Professionals	13,095	13,150	14,505
Postdoctoral Associates	6,070	6,100	6,940
Graduate Students	35,415	35,705	40,775
Undergraduate Students	22,745	22,970	25,595
K-12 Students	11,415	12,625	13,250
K-12 Teachers	61,235	62,545	64,110
Total, Number of People	191,245	194,670	211,805

Senior Researchers include scientists, mathematicians, engineers, and educators receiving funding through NSF awards. These include both researchers who are principal or co-principal investigators on research and education projects, and researchers working at NSF-supported centers and facilities.

Other Professionals are individuals who may or may not hold a doctoral degree or its equivalent, who are considered professionals, but are not reported as senior researchers, postdoctoral associates, or students. Examples are technicians, systems experts, etc.

Postdoctoral Associates are individuals who have received Ph.D., M.D., D.Sc., or equivalent degrees and who are not members of the faculty of the performing institution. Roughly 98 percent of postdoctoral associates are supported through funds included in research projects, centers or facilities awards. Others are recipients of postdoctoral fellowships.

Graduate Students include students compensated from NSF grant funds. Approximately 12 percent of these students receive support through programs such as NSF Graduate Research Fellowships, Integrative Graduate Education and Research Traineeship, and NSF Graduate Teaching Fellowships in K-12 Education. The balance assists senior researchers or postdoctoral associates in performing research, and are supported through funds included in research projects, centers, or facilities awards. NSF provides support for approximately five percent of the science and engineering graduate students in the U.S.

Undergraduate Students include students enrolled in technical colleges or baccalaureate programs compensated from NSF grant funds. They may be assisting senior researchers or postdoctoral associates in performing research, or participating in NSF programs aimed at undergraduate students, such as Research Experiences for Undergraduates and the Louis Stokes Alliances for Minority Participation.

K-12 Students are those attending elementary, middle, and secondary schools. They are supported through program components that directly engage students in science and mathematics experiences such as teacher and student development projects.

K-12 Teachers include teachers at elementary, middle, and secondary schools. These individuals actively participate in intensive professional development experiences in the sciences and mathematics.

NSF By Account

(Actual Dollars in Millions - Current Dollars)

Fiscal Year	Research & Related Activities	Education & Human Resources	Academic Research Infrastructure	Major Research Equipment & Facilities Construction	Agency Operations & Award Management	Office of Inspector General	National Science Board	NSF
1951	0.03	-	-	-	0.13	-	-	0.15
1952	1.40	1.54	-	-	0.53	-	-	3.47
1953	2.14	1.41	-	-	0.88	-	-	4.43
1954	4.52	1.89	-	-	1.55	-	-	7.96
1955	8.86	2.08	-	-	1.55	-	-	12.49
1956	10.79	3.52	-	-	1.68	-	-	15.99
1957	21.98	14.30	-	-	2.35	-	-	38.63
1958	27.37	19.21	-	-	2.93	-	-	49.51
1959	66.33	61.29	-	-	5.26	-	-	132.88
1960	88.35	63.74	-	-	6.51	-	-	158.60
1961	103.98	63.44	-	-	7.57	-	-	174.99
1962	173.26	78.58	-	-	8.98	-	-	260.82
1963	218.90	90.99	-	-	10.87	-	-	320.75
1964	239.95	102.58	-	-	12.05	-	-	354.58
1965	282.44	120.41	-	-	13.12	-	-	415.97
1966	328.63	124.31	-	-	13.09	-	-	466.02
1967	327.70	123.36	-	-	14.04	-	-	465.10
1968	350.20	134.71	-	-	15.38	-	-	500.29
1969	292.90	123.11	-	-	16.49	-	-	432.50
1970	316.41	126.41	-	-	19.68	-	-	462.49
1971	369.37	105.00	-	-	21.77	-	-	496.14
1972	482.43	93.73	-	-	24.56	-	-	600.72
1973	519.42	62.23	-	-	28.62	-	-	610.27
1974	533.29	80.71	-	-	31.66	-	-	645.65
1975	581.23	74.03	-	-	37.87	-	-	693.13
1976	619.72	62.48	-	-	42.23	-	-	724.42
1977	671.98	74.26	-	-	45.53	-	-	791.77
1978	734.69	73.86	-	-	48.70	-	-	857.25
1979	791.76	80.41	-	-	54.77	-	-	926.93
1980	836.83	80.06	-	-	58.24	-	-	975.13
1981	900.36	75.70	-	-	59.21	-	-	1,035.27
1982	909.75	26.20	-	-	63.18	-	-	999.14
1983	1,013.02	22.98	-	-	65.70	-	-	1,101.69
1984	1,177.70	62.97	-	-	66.26	-	-	1,306.92
1985	1,344.56	90.56	-	-	71.95	-	-	1,507.07
1986	1,329.64	91.69	-	-	71.84	-	-	1,493.17
1987	1,439.97	109.88	-	-	77.77	-	-	1,627.62
1988	1,481.31	156.79	-	-	84.47	-	-	1,722.57
1989	1,600.53	194.06	-	-	91.29	-	-	1,885.88
1990	1,696.56	230.41	0.41	-	96.35	2.33	-	2,026.06
1991	1,868.45	331.91	39.02	-	101.23	2.89	-	2,343.49
1992	1,940.48	459.44	33.36	-	109.99	3.86	-	2,547.13
1993	2,046.31	505.06	49.75	34.07	110.84	3.69	-	2,749.73
1994	2,168.36	569.03	105.38	17.04	123.49	3.92	-	2,987.21
1995	2,281.46	611.88	117.46	126.00	129.01	4.46	-	3,270.27
1996	2,327.80	601.16	70.89	70.00	132.50	3.98	-	3,206.33
1997	2,433.93	619.14	30.02	76.13	134.27	5.33	-	3,298.82
1998	2,572.62	633.16	-	78.21	136.95	4.80	-	3,425.73
1999	2,821.61	662.48	-	56.71	144.08	5.41	-	3,690.28
2000	2,979.90	683.58	-	105.00	149.28	5.60	-	3,923.36
2001	3,372.30	795.42	-	119.24	166.33	6.58	-	4,459.87
2002	3,615.97	866.11	-	115.35	169.93	6.70	-	4,774.06
2003	4,054.43	934.88	-	179.03	189.42	8.70	2.88	5,369.34
2004	4,293.34	944.10	-	183.96	218.92	9.47	2.22	5,652.01
2005	4,234.82	843.54	-	165.14	223.45	10.17	3.65	5,480.77
2006	4,351.03	798.48	-	233.81	247.06	11.47	3.94	5,645.79
2007	4,656.33	797.76	-	166.21	248.49	11.92	3.65	5,884.37
2008 Estimate [1/]	4,821.47	725.60	-	220.74	281.79	11.43	3.97	6,065.00
2009 Request	5,593.99	790.41		147.51	305.06	13.10	4.03	6,854.10

[1/] EPSCoR funding will be moved from Education and Human Resources to Research and Related Activities in FY 2008.

NSF By Account

(FY Actuals - FY 2008 Constant Dollars in Millions)

Fiscal Year	Research & Related Activities	Education & Human Resources	Academic Research Infrastructure	Major Research Equipment & Facilities Construction	Agency Operations & Award Management	Office of Inspector General	National Science Board	NSF
1951	0.18	-	-	-	0.88	-	-	1.07
1952	9.54	10.47	-	-	3.61	-	-	23.61
1953	14.28	9.41	-	-	5.85	-	-	29.54
1954	29.82	12.47	-	-	10.20	-	-	52.49
1955	57.96	13.61	-	-	10.11	-	-	81.67
1956	68.77	22.44	-	-	10.71	-	-	101.91
1957	135.01	87.83	-	-	14.44	-	-	237.28
1958	163.20	114.50	-	-	17.49	-	-	295.18
1959	389.36	359.76	-	-	30.88	-	-	780.00
1960	512.43	369.69	-	-	37.75	-	-	919.87
1961	594.56	362.77	-	-	43.29	-	-	1,000.62
1962	979.74	444.34	-	-	50.77	-	-	1,474.84
1963	1,222.46	508.13	-	-	60.68	-	-	1,791.26
1964	1,324.23	566.12	-	-	66.52	-	-	1,956.87
1965	1,532.33	653.27	-	-	71.17	-	-	2,256.77
1966	1,745.60	660.31	-	-	69.53	-	-	2,475.43
1967	1,686.26	634.78	-	-	72.27	-	-	2,393.31
1968	1,740.28	669.43	-	-	76.42	-	-	2,486.13
1969	1,391.93	585.05	-	-	78.36	-	-	2,055.35
1970	1,425.77	569.62	-	-	88.66	-	-	2,084.05
1971	1,585.23	450.63	-	-	93.43	-	-	2,129.29
1972	1,977.11	384.13	-	-	100.66	-	-	2,461.91
1973	2,038.83	244.27	-	-	112.34	-	-	2,395.43
1974	1,952.34	295.48	-	-	115.89	-	-	2,363.71
1975	1,927.41	245.49	-	-	125.57	-	-	2,298.47
1976	1,916.74	193.25	-	-	130.60	-	-	2,240.59
1977	1,933.55	213.68	-	-	131.01	-	-	2,278.23
1978	1,980.64	199.13	-	-	131.28	-	-	2,311.05
1979	1,975.35	200.60	-	-	136.63	-	-	2,312.58
1980	1,919.51	183.64	-	-	133.59	-	-	2,236.74
1981	1,881.03	158.15	-	-	123.69	-	-	2,162.88
1982	1,778.91	51.23	-	-	123.54	-	-	1,953.68
1983	1,897.07	43.03	-	-	123.03	-	-	2,063.14
1984	2,126.98	113.72	-	-	119.66	-	-	2,360.36
1985	2,351.97	158.40	-	-	125.86	-	-	2,636.23
1986	2,272.98	156.74	-	-	122.80	-	-	2,552.53
1987	2,398.97	183.06	-	-	129.56	-	-	2,711.58
1988	2,392.57	253.24	-	-	136.43	-	-	2,782.24
1989	2,488.45	301.72	-	-	141.93	-	-	2,932.09
1990	2,543.28	345.40	0.61	-	144.44	3.49	-	3,037.22
1991	2,699.61	479.55	56.38	-	146.25	4.17	-	3,385.97
1992	2,734.91	647.53	47.01	-	155.02	5.44	-	3,589.91
1993	2,820.11	696.05	68.57	46.95	152.75	5.08	-	3,789.51
1994	2,925.41	767.70	142.17	22.99	166.60	5.28	-	4,030.16
1995	3,014.56	808.49	155.20	166.49	170.47	5.89	-	4,321.10
1996	3,017.84	779.37	91.91	90.75	171.77	5.15	-	4,156.79
1997	3,101.29	788.90	38.25	97.00	171.09	6.79	-	4,203.33
1998	3,238.71	797.09	-	98.45	172.40	6.04	-	4,312.70
1999	3,506.14	823.20	-	70.46	179.03	6.72	-	4,585.56
2000	3,629.52	832.60	-	127.89	181.82	6.82	-	4,778.66
2001	4,012.76	946.48	-	141.89	197.92	7.83	-	5,306.88
2002	4,221.87	1,011.24	-	134.68	198.40	7.82	-	5,574.01
2003	4,639.95	1,069.89	-	204.88	216.77	9.96	3.30	6,144.75
2004	4,789.60	1,053.23	-	205.22	244.22	10.56	2.48	6,305.32
2005	4,584.49	913.19	-	178.78	241.90	11.01	3.95	5,933.32
2006	4,569.37	838.55	-	245.54	259.46	12.05	4.14	5,929.10
2007	4,769.10	817.08	-	170.24	254.51	12.21	3.74	6,026.87
2008 Estimate[1/]	4,821.47	725.60	-	220.74	281.79	11.43	3.97	6,065.00
2009 Request	5,469.60	772.83	-	144.23	298.28	12.81	3.94	6,701.69

[1/] EPSCoR funding will be moved from Education and Human Resources to Research and Related Activities in FY 2008.

National Science Foundation Current Authorizations

LEGISLATION	FY 2007 Actual	Authorization Levels FY 2007	FY 2008	FY 2009	FY 2008 Estimate
			(Dollars in Millions)		
National Science Foundation Act of 1950 (P.L. 81-507) [1]					
Scholarships and Graduate Fellowships			*within limits of funds made available for this purpose*		
General Authority			*within the limits of available appropriations*		
Administering Provisions			*to make such expenditures as may be necessary*		
International Cooperation and Coordination with Foreign Policy			*within the limit of appropriated funds*		
Contract Arrangements			*utilize appropriations available*		
NSF Authorization Act of 2002 (P.L.107-368) [2]		$9,839.26			
America Competes Act (P.L.110-69) [3]	$5,884.37		$6,600.00	$7,326.00	$6,065.00
Account and Program Specific					
Research and Related Activities	$4,764.70		$5,156.00	$5,742.30	$4,821.47
Experimental Program to Stimulate Competitive Research	$102.11		$120.00	$133.20	$111.10
Faculty Early Career Development (CAREER) Program	$187.40		$165.40	$183.60	$167.76
Graduate Research Fellowship Program	$8.04		$9.00	$10.00	$8.14
Integrative Graduate Education and Research Traineeship Program	$42.37		$47.30	$52.50	$42.37
Major Research Instrumentation	$90.00		$115.00	$123.10	$93.90
Professional Science Master's Degree Program	-		$10.00	$12.00	-
Research Experiences for Undergraduates	$63.28		$61.60	$68.40	$57.73
Education and Human Resources	$698.00		$896.00	$995.00	$725.60
Advanced Technology Education	$50.58		$52.00	$57.70	$51.62
Graduate Research Fellowship Program	$86.18		$96.60	$107.20	$88.10
Integrative Graduate Education and Research Traineeship Program	$25.27		$27.10	$30.10	$25.00
Mathematics and Science Education Partnerships	$45.95		$100.00	$111.00	$48.50
Science, Mathematics, Engineering, and Technology Talent Expansion Program	$28.90		$40.00	$50.00	$29.70
Robert Noyce Scholarship Program	$10.30		$89.80	$115.00	$10.80
Major Research Equipment and Facilities Construction	$190.90		$245.00	$262.00	$220.74
Agency Operations and Award Management	$246.80		$285.60	$309.76	$281.79
National Science Board	$4.00		$4.05	$4.19	$3.97
Office of the Inspector General	$11.40		$12.35	$12.75	$11.43

LEGISLATION (cont.)	FY 2007 Actual	Authorization Levels FY 2007	FY 2008	FY 2009	FY 2008 Estimate
Program Specific					
Computer and Network Security Capacity Building Grants	$20.00	$20.00			
Computer and Network Security Research Centers[4]	$14.00	$36.00			
Computer and Network Security Research Grants[4]	$50.00	$60.00			
Graduate Traineeships in Computer and Network Security	$15.00	$20.00			
21st Century Nanotechnology Research and Development Act (P.L.108-153)					
Nanoscale Science and Engineering	$388.69	$449.00	$476.00		$388.69
National Earthquake Hazards Reduction Program Reauthorization Act of 2003 (P.L.108-360)	$54.20	$40.31	$41.52	$42.77	$55.63
National Windstorm Impact Reduction Act of 2004 (P.L.108-360)	$6.20	$9.40	$9.40		*
Consolidated Appropriations Act, 2001 (P.L.106-554); Small Business Technology Transfer Program Reauthorization Act of 2001 (P.L.107-50)					
Small Business Innovation Research (SBIR) Program	$97.20	2.5% of research funds (SBIR)			$97.85
Small Business Technology Transfer (STTR) Program	$11.47	0.3% of research funds (STTR)			$11.52

[1]Organic language establishing NSF, authorization and appropriation language may not correspond to current accounts and programs.

[2]Authorized agency funding through FY 2007; authorization levels not specified below agency level.

[3] Authorizes agency funding for FYs 2008-100; authorizes agency, account, and various program levels.

[4] Excludes graduate student support for US citizens and permanent residents.

* Actual amounts will be reported after awards are completed.

RESEARCH AND RELATED ACTIVITIES $5,593,990,000

The FY 2009 Budget Request for the Research and Related Activities (R&RA) Appropriation is $5,593.99 million, an increase of $772.52 million, or 16.0 percent, above the FY 2008 Estimate of $4,821.47 million. Support from the R&RA Appropriation enables U.S. leadership and progress across the frontiers of scientific and engineering research and education.

Sustained, targeted investment by NSF in fundamental science and engineering advances discovery and learning and spurs innovation. Such transformational work holds great promise for meeting the myriad social, economic, and environmental challenges faced by both the Nation and the world. And as global competition in science and engineering becomes more intense, continued support for high-risk, high-reward research is vital to U.S. competitiveness.

To meet these challenges set forth in the American Competitiveness Initiative (ACI) and America COMPETES Act, the R&RA portfolio for FY 2009 places priority on potentially transformative activities involving all fields of science and engineering.

Research and Related Activities
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Biological Sciences	$608.54	$612.02	$675.06	$63.04	10.3%
Computer and Information Science and Engineering	526.68	534.53	638.76	104.23	19.5%
Engineering	629.99	636.87	759.33	122.46	19.2%
Geosciences	745.85	752.66	848.67	96.01	12.8%
Mathematical and Physical Sciences	1,150.73	1,167.31	1,402.67	235.36	20.2%
Social, Behavioral and Economic Sciences	214.54	215.13	233.48	18.35	8.5%
Office of Cyberinfrastructure	182.42	185.33	220.08	34.75	18.8%
Office of International Science and Engineering[1]	40.36	41.34	47.44	6.10	14.8%
Office of Polar Programs	438.43	442.54	490.97	48.43	10.9%
Integrative Activities[2]	219.45	232.27	276.00	43.73	18.8%
U.S. Arctic Research Commission	1.45	1.47	1.53	0.06	4.1%
Total, Research and Related Activities	$4,758.44	$4,821.47	$5,593.99	$772.52	16.0%

Totals may not add due to rounding.

[1] OISE FY 2007 Actual excludes $5.46 million provided to NSF by the U.S. Department of State for an award to the U.S. Civilian Research and Development Foundation.

[2] Includes funding for EPSCoR for all years shown for comparability. Prior to FY 2008, the program was funded through the Education and Human Resources appropriation.

RESEARCH AND RELATED ACTIVITIES

Appropriation Language

For necessary expenses in carrying out the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-1875), and the Act to establish a National Medal of Science (42 U.S.C. 1880-1881); services as authorized by 5 U.S.C. 3109; maintenance and operation of aircraft and purchase of flight services for research support; acquisition of aircraft; and authorized travel; ~~$4,821,474,000,~~*$5,593,990,000*, to remain available until September 30, ~~2009,~~*2010*, of which not to exceed ~~$510,000,000~~*$540,000,000* shall remain available until expended for polar research and operations support, and for reimbursement to other Federal agencies for operational and science support and logistical and other related activities for the United States Antarctic program*: Provided* That, from funds specified in the fiscal year ~~2008~~*2009* budget request for icebreaking services, up to ~~$57,000,000~~*$54,000,000* shall be available for the procurement of polar icebreaking services: *Provided further*, That the National Science Foundation shall only reimburse the Coast Guard for such sums as are agreed to according to the existing memorandum of agreement*:* ~~*Provided further*, That $2,240,000 shall be transferred to the "Office of Science and Technology Policy" for costs associated with the Science and Technology Policy Institute/RaDiUS:~~*Provided further*, That receipts for scientific support services and materials furnished by the National Research Centers and other National Science Foundation supported research facilities may be credited to this appropriation. *(Science Appropriations Act, 2008.)*

Research and Related Activities
FY 2009 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Carryover/ Recoveries	P.L. 110-161 Rescission	Transfers[1]	Expired	Total Resources	EPSCoR	Total Adjusted Resources	Obligations Incurred/ Est.
FY 2007 Approp.	$4,665.95	$8.28	-	$5.46	-$0.72	$4,678.97	$102.11	$4,781.08	$4,758.44
FY 2008 Estimate[2]	4,821.47	22.63	-17.17	-		4,826.93	-	4,826.93	4,826.93
FY 2009 Request[2]	5,593.99	-	-	-		-	-	5,593.99	5,593.99
$ Change from FY 2008									$767.06
% Change from FY 2008									15.9%

Totals may not add due to rounding.

[1]Transferred from the U.S. International Development Cooperation Agency for an award to the U.S. Civilian Research and Development Foundation.

[2]The FY 2008 Estimate for R&RA includes $111.10 million for EPSCoR. The FY 2009 Request for R&RA includes $113.5 million for EPSCoR. Prior to FY 2008, EPSCoR was funded through the Education and Human Resources appropriation.

Adjustments to Base

In FY 2007, 102.11 million is being reported for EPSCoR in the Integrative Activities activity within the R&RA appropriation. The R&RA FY 2009 Summary Statement table includes information for EPSCoR from FY 2007 through FY 2009.

RESEARCH AND RELATED ACTIVITIES
FY 2009 Performance Highlights

The table below shows the strategic planning and evaluation framework for activities funded through the R&RA appropriation. This framework was established in the NSF Strategic Plan for FY 2006-2011. NSF's strategic outcome goals are assessed annually by the Advisory Committee for GPRA Performance Assessment. Investments are assessed further using the Program Assessment Rating Tool (PART). Additional details are available in the Performance Information section of this document.

Research and Related Activities
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actuals	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Discovery[1]	$3,042.74	$3,099.48	$3,670.27	$570.79	18.4%
Learning	271.62	272.75	280.10	7.35	2.7%
Research Infrastructure	1,395.31	1,396.82	1,573.35	176.53	12.6%
Stewardship	48.77	52.42	70.27	17.85	34.1%
Total, NSF	$4,758.44	$4,821.47	$5,593.99	$772.52	16.0%

Totals may not add due to rounding.

[1] Funding for EPSCoR is shown in all years for comparability. Prior to FY 2008, EPSCoR was funded through the Education and Human Resources appropriation.

BIOLOGICAL SCIENCES $675,060,000

The FY 2009 Budget Request for the Directorate for Biological Sciences (BIO) is $675.06 million, an increase of $63.04 million, or 10.3 percent, over the FY 2008 Estimate of $612.02 million.

Biological Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Molecular and Cellular Biosciences (MCB)	$111.50	$112.51	$126.10	$13.59	12.1%
Integrative Organismal Systems (IOS)	202.31	199.86	216.27	16.41	8.2%
Environmental Biology (EB)	109.60	110.86	125.64	14.78	13.3%
Biological Infrastructure (BI)	80.23	86.94	86.99	0.05	0.1%
Emerging Frontiers (EF)	104.90	101.85	120.06	18.21	17.9%
Total, BIO	$608.54	$612.02	$675.06	$63.04	10.3%

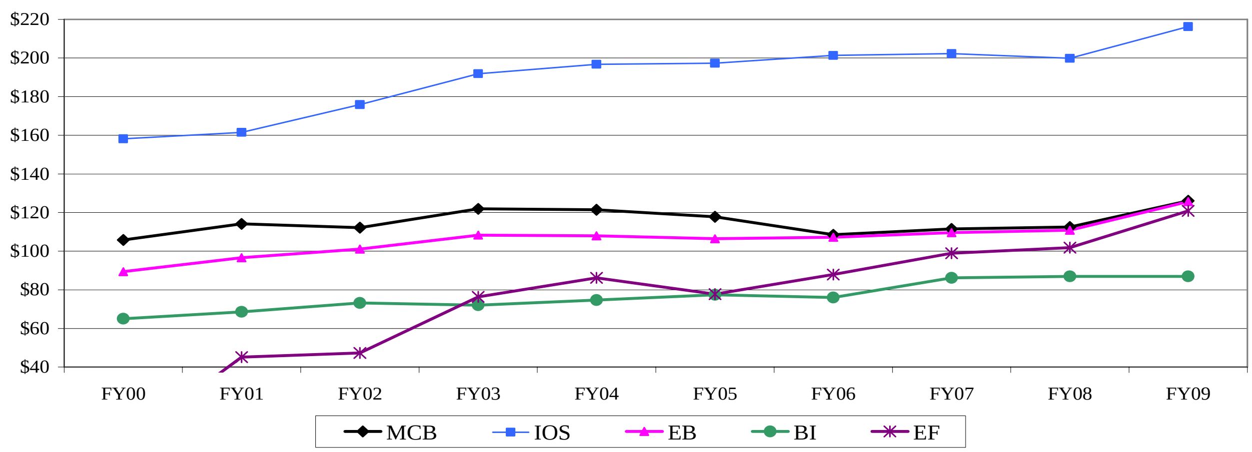
Totals may not add due to rounding.

The Plant Genome Research program has been assigned as a program element within the IOS Subactivity. Further details are provided in the restructuring cross-walk table.

The mission of the BIO Directorate is to enable discoveries for understanding life. Through its investments in innovative and transformative research, BIO advances the frontiers of knowledge in the life sciences, increases our understanding of complex living systems, and provides the theoretical basis for advances in other sciences and engineering.

Biological research leading to the development of novel technologies to generate, store, and analyze molecular, genetic, cellular, organismal, evolutionary, and ecological data is stimulating innovation in the physical sciences, engineering, and computer science, a primary goal of the Administration's American Competitiveness Initiative (ACI).

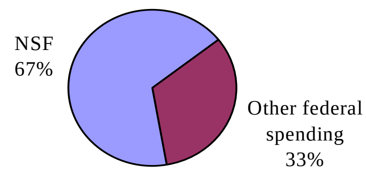
BIO Subactivity Funding
(Dollars in Millions)



RELEVANCE

NSF is the major source of federal funding for non-medical, fundamental life sciences research at academic institutions, providing 67 percent of this support. Issues of national importance related to the environment, economy, agriculture, and human welfare require an understanding of how complex living systems function and interact with non-living systems. Research supported by BIO enhances this understanding. As the physical, computational, mathematical, and engineering fields increasingly use living systems to address major questions in their areas, it is essential to maintain a robust investment in the non-medical biological sciences. Biological research uncovers the principles that form the foundation for the interdisciplinary grand challenge questions.

Federal Support for Basic Research in Non-Medical Biological Sciences at Academic Institutions



Living organisms have evolved mechanisms for efficiently using energy, producing an endless array of novel compounds, and storing information in a highly compact, adaptable format. Fundamental biological research is working to make this 3.5 billion years of biological innovation available to inform the next generation of nano-, bio-, and information technologies. Basic research to understand how genomic information is encoded and specifically expressed will provide new and important opportunities to improve existing computational tools, and develop new computational technologies with broad application in the life and physical sciences and engineering.

The explosion of heterogeneous data about complex biological systems is providing rich opportunities for developing innovative cyberinfrastructure to integrate knowledge. Integrating knowledge about individual biological units into networks, from the molecular level to the ecosystem scale, is a leading challenge in biology. Connecting individual networks to understand complex biological webs will require the collaborative effort of all biological sub-disciplines working with other fields of science and engineering. The focus on multiple scales of biological organization builds on the current vigor of biological inquiry, but envisions a stronger conceptual and theoretical basis as researchers strive to uncover basic principles of organization, form, and function. This will enable breakthroughs in nanotechnology and biotechnology.

BIO is uniquely suited to advance our understanding of complex biological systems, in keeping with the Administration's FY 2009 R&D priorities, through its ability to integrate research across the entire range of biological systems and scales. Biological concepts are integral to wide-ranging areas of science, including national priorities such as nanotechnology, biotechnology, bioengineering, climate change science, and water. Mathematical modeling and computational simulations have become critical to leading edge biology by advancing our understanding of non-linear systems such as invasive species dynamics and gene regulation.

BIO has made significant contributions to understanding the changing dynamics of the biosphere through investment in interdisciplinary research. Continued investment will improve the capabilities for predicting a changing biosphere, and will foster development of broadly-testable theories that link the biosphere, geosphere, and atmosphere in a project like the National Ecological Observatory Network (NEON).

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, BIO..................……………………………………………………………..$612.02

Enhanced support for disciplinary and interdisciplinary research across BIO's core programs is the highest priority in FY 2009. The FY 2009 requested increase for core programs will help to restore funding rates and numbers of research awards to FY 2007 levels following a projected decrease of 5% across the board along with a decrease in funding rates to 15% in FY 2008. Included will be support for a new activity, Life in Transition. The role of the living world in adapting to and shaping a changing Earth is found in the fundamental questions at the junction of the life and physical sciences. NSF is the best positioned agency to lead a comprehensive, trans-disciplinary approach to understanding the changing biosphere.

Molecular and Cellular Biosciences (MCB) +$13.59

Disciplinary and interdisciplinary research in the MCB core will increase to enhance support for projects that incorporate metagenomics, theoretical and mathematical modeling, synthetic biology, small RNA biology, and the role of the intracellular environment on the dynamic structure and function of complex biomolecules. MCB investments in the new Life in Transitions activity will contribute to advancing our understanding of the origin of life through synthetic biology research; and the new Adaptive Systems Technology activity brings biological and physical systems into convergence, to enable revolutionary advances in the development of novel adaptive systems by translating advances in neuroscience into engineered systems.

Integrative Organismal Systems (IOS) +$16.41

Disciplinary and interdisciplinary research in the IOS core will increase to emphasize integrative research, with special attention to new activities in Adaptive Systems Technology, Life in Transition, and Dynamics of Water Processes in the Environment. IOS will support innovative studies that promise to provide a deeper understanding of the properties emerging from the interactions of the myriad of processes and structures of living systems. In addition, enhanced support for the Plant Genome Research Program will build on the prior ten years of investment as part of the National Plant Genome Initiative (NPGI). Continued support for genome-enabled plant biology research will build on the knowledge and research resources and tools accumulated to date, including continued support for collaborations between U.S. scientists and scientists in developing countries that focus on plant genomics and plant biotechnology.

Environmental Biology (DEB) +$14.78

Disciplinary and interdisciplinary research in the DEB core will emphasize support for biodiversity research with increased emphasis on resolving uncertainties regarding the ancestry of microbial life forms. The explosion of genomics-level information about living organisms has opened up new avenues of inquiry that relate the adaptability and dynamics of populations to their genetic makeup. DEB will continue to play a major role in emphasizing research to reduce uncertainties in global climate projections. Special attention will be placed on the new activities for Dynamics of Water Processes in the Environment and Life in Transition.

Biological Infrastructure (DBI) +$0.05

Funding for DBI remains flat for FY 2009, except for an increase for Stewardship activities. Programmatic evaluations for all DBI programs will continue in FY 2009 with the goal to identify those research and human resources that are most effective and essential to advancing the frontiers in the biological sciences.

Emerging Frontiers (EF) +$18.21

Programmatic funding in EF provides seed funds for new transformational research activities at the leading edge of biology and science. EF also provides support and oversight for biological centers and facilities. In FY 2009, EF will provide venture funding for the Life in Transition activity, and will contribute to the NSF-wide investment, Dynamics of Water Processes in the Environment. In addition, significant investment will be made to support Centers and facilities, including: establishment of the Center for Research at the Interface of the Mathematical and Biological Sciences, enhanced support for the Plant Science Cyberinfrastructure Collaborative, and enhanced support for the Center for Environmental Implications of Nanotechnology begun in FY 2008. Support for NEON will increase for continued project development to prepare for final design reviews in FY 2009.

Subtotal, Changes +$63.04

FY 2009 Request, BIO……………………………………………………………...……..$675.06

Summary of Major Changes in Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, BIO………………………………………………………………........$612.02

<u>Discovery</u> +$54.80

Core BIO Investments (+$33.44 million).

Increasing support for basic research in biology will yield insights that can be used innovatively to produce the next generation of nano-, bio-, and information technologies. Support of fundamental scientific discovery in areas such as these will have major impacts on quality of life, technological innovation, economic competitiveness, and new job growth – high priorities of the ACI. Support will focus on: unlocking the genetic code; network and cross-scale analysis from cells to societies; theoretical and conceptual basis of biology; and changing dynamics of the biosphere.

Life in Transition (+$10.0 million).

Funding will support research on the indispensable properties of living systems; the fundamental characteristics of biological energy systems and their potential utility; and the mechanisms and principles of resilience and sustainability that enable some life forms to survive, adapt to, and transform their environment. In partnership with the National Aeronautics and Space Administration (NASA), Life in Transition research will also determine the biogeochemical conditions that enabled molecules to cross the barrier between non-living organic chemistry and life, findings that can define and direct the search for life or proto-life elsewhere in our solar system.

Adaptive Systems Technology (AST) (+3.49 million).

BIO will contribute to this cross-Foundation activity by supporting research to determine how living systems solve problems of form and function. This research will enable new generations of innovative machines to explore and expand human abilities using systems that interface with or mimic living neural networks. Research will be supported on neurosystems design characteristics and principles that can lead to the development of new materials and technologies such as neural networks and mechano-responsive biomaterials that mimic natural systems in intelligence, adaptability, resilience, and robustness. Living and engineered systems will reciprocally inform fundamental understanding in areas such as movement control, and sensing and adaptation to changing environments. This research will enable new generations of biologically-inspired innovative technologies with great potential impact on U.S. competitiveness.

Dynamics of Water Processes in the Environment (+$4.21 million).
Coordinated research on fresh water is critical to human health and economic prosperity. BIO's investments focus largely on research to understand the resilience that the presence of living organisms confers to freshwater ecological systems. A major emphasis will be on ecological forecasting to understand the impacts and feedbacks between climate and ecological change.

Centers (+$3.66 million).

- *Centers for Analysis and Synthesis (+$4.80 million).* The Plant Science Cyberinfrastructure Collaborative established in FY 2008 will receive enhanced support to use advanced computational and cyberinfrastructure capabilities and expertise to craft solutions to an evolving array of grand challenges in plant science (+$2.48 million). The Center for Research at the Interface of the Mathematical and Biological Sciences (CIMBS) will be established in FY 2009 to stimulate research and education at the interface of the mathematical and biological sciences (+$3.10 million). CIMBS will play a critical role in addressing national needs, particularly in the area of modeling infectious diseases of animals and plants, providing useful knowledge to policy makers, government agencies, and society. A total investment of $16 million over 5 years in this center includes partnership contributions from the Mathematical & Physical Sciences Directorate, Department of Homeland Security and United States Department of Agriculture. Initiation of CIMBS was deferred from FY 2008. Other centers for analysis and synthesis will see decreasing out-year adjustments. (-$780,000)

- *Behavioral Neuroscience Science and Technology Center (-$1.19 million).* Established in FY 2000, this center will receive a final year of funding in FY 2009.

- *Center for Environmental Implications of Nanotechnology (CEIN) (+$50,000).* CEIN will receive a small increase as it ramps up to full year operations to conduct fundamental research on the interactions between nano-particles, materials, and the living world at all scales. Total investment of $5.0 million in this important center includes partnership contributions from across NSF and the Environmental Protection Agency.

<u>Research Infrastructure</u> +$6.0

NEON (+$6.0 million). Increased investment in the National Ecological Observatory Network (NEON) will sustain project design and development activities until completion of the preliminary and final design reviews, expected in FY 2008 and FY 2009, and certification for construction readiness.

<u>Stewardship</u> +$2.24

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$63.04

FY 2009 Request, BIO…………………………..…………………………………….……..….$675.06

NSF-WIDE INVESTMENTS

In FY 2009, the Directorate for Biological Sciences will support research and education efforts related to broad, Foundation-wide investments in a number of areas including NSF's multidisciplinary priority areas and the Administration's interagency R&D priorities.

BIO NSF-wide Investments
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Adaptive Systems Technology			$3.49	$3.49	N/A
Biocomplexity in the Environment	9.43	-	-	-	N/A
Climate Change Science Program	15.10	15.10	15.10	-	-
Cyber-enabled Discovery & Innovation	-	1.00	2.65	1.65	165.0%
Cyberinfrastructure	90.50	97.13	99.78	2.65	2.7%
Dynamics of Water Processes in the Environment	-	-	4.21	4.21	N/A
Human and Social Dynamics	0.50	0.50	-	-0.50	-100.0%
International Polar Year	2.00	2.00	-	-2.00	-100.0%
Mathematical Sciences	1.11	-	-	-	N/A
National Nanotechnology Initiative	52.55	55.55	56.60	1.05	1.9%
Networking and Information Technology R&D	83.50	83.50	86.15	2.65	3.2%

Adaptive Systems Technology (AST): A total of $3.49 million will support research to determine how living systems solve problems of form and function, aiding the development of innovative technologies that mimic natural systems in intelligence, adaptability, resilience, and robustness, including neural networks and mechano-responsive biomaterials.

Biocomplexity in the Environment, Human and Social Dynamics, International Polar Year, Mathematical Sciences: With the conclusion of these NSF-wide investments, components of each have been transferred to core programs for continued support.

Climate Change Science Program (CCSP): CCSP was established to respond to the challenge of understanding climate and climate variability. A total of $15.1 million will continue support for research to address ecological rates of change and related impacts on species diversity. This includes support for programs that specifically address terrestrial ecosystem responses to climate change through experimental modeling and laboratory studies, including research through the Long Term Ecological Research (LTER) program.

Cyber-enabled Discovery & Innovation (CDI): CDI capitalizes on the discovery potential of fundamental scientific research to inform and expand today's computational capabilities. BIO's investment in the Plant Science Cyberinfrastructure Collaborative will enable new conceptual advances in biology through integrative, computational thinking. The collaborative will create intellectual synergy among biologists, computer and information scientists, mathematicians, engineers, and others to drive discovery and address the grand challenges in plant science. An investment of $2.65 million in BIO will contribute to the agency's strategic goals of advancing the frontier of knowledge by creating new computational concepts, methods, and tools, and will also contribute to the preparation of a workforce with the computational competencies critical to continued U.S. competitiveness.

Cyberinfrastructure (CI): Improving high-end computing capability is an important objective of ACI and is expected to increase our understanding of complexity across biological systems by accelerating the pace and nature of biological discovery in the 21st century. A total of $99.78 million (+$2.65 million) will support databases and informatics tools within BIO, including the Protein Data Bank (PDB), the international repository and primary source for information about the structure of biological macromolecules, and The Arabidopsis Information Resource (TAIR). FY 2009 funds will enhance support for the Plant Science Cyberinfrastructure Collaborative that will enable new conceptual advances in biology through integrative, computational thinking. The collaborative will create intellectual synergy among biologists, computer and information scientists, mathematicians, engineers, social scientists and others to drive discovery and address grand challenges in plant science.

Dynamics of Water Processes in the Environment (WATER): A total of $4.21 million will support research on the resilience that is conferred by the presence of living organisms in freshwater ecological systems. A major emphasis will be on the ecological forecasting necessary to understand impacts and feedbacks associated with climate and environmental change.

National Nanotechnology Initiative (NNI): A total of $56.60 million (+$1.05 million) will continue support for research on biosystems at the nanoscale that exhibit novel properties. Potential applications of findings include exploiting functions of cellular organelles and nanoscale sensory systems, and the development of nano- devices for research in genomics, proteomics, and cell biology. BIO will enhance support for the Center for Environmental Implications of Nanotechnology.

Networking and Information Technology Research and Development (NITRD): A total of $86.15 million (+$3.0 million) will continue support for Human-Computer Interaction and Information Management (HCI&IM) to increase the benefit of computer technologies for biology; and for Software Design and Productivity (SDP) research leading to fundamental advances in concepts, methods, techniques, and tools for software design. These efforts are critical to the future of research technologies relevant to a broad range of scientific disciplines and related to ACI priorities.

QUALITY

BIO maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. The percent of research funds allocated to projects that undergo external merit review was 97 percent in FY 2007, the last year for which complete data exist.

To ensure the highest quality in processing and recommending proposals for awards, BIO convenes Committees of Visitors (COV), which are composed of qualified external evaluators who review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of NSF's investments. In June 2008, BIO will convene COVs for both the Division of Molecular and Cellular Biosciences and Integrative Organismal Systems.

The Directorate for Biological Sciences also receives advice from the Advisory Committee for Biological Sciences (BIOAC) on such issues as: the mission, programs, and goals that can best serve the scientific community; how BIO can promote quality graduate and undergraduate education in the biological sciences; and priority investment areas in biological research. The BIOAC meets twice a year. Members from academic institutions and industry represent a cross section of biology. The Committee is balanced with respect to gender, underrepresented minorities, and geographic regions.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four goals stated in the FY 2006-2011 Strategic Plan. These goals provide a framework for progress in fundamental research and education and facilitate budget and performance integration.

Biological Sciences

By Strategic Outcome Goal

(Dollars in Millions)

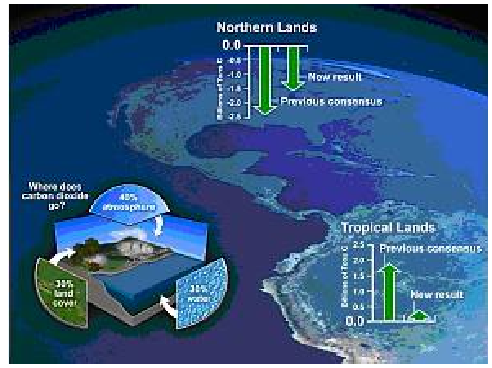
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Discovery	$443.42	$435.86	$490.66	$54.80	12.6%
Learning	47.17	43.14	43.14	-	-
Research Infrastructure	112.38	127.02	133.02	6.00	4.7%
Stewardship	5.57	6.00	8.24	2.24	37.3%
Total, BIO	$608.54	$612.02	$675.06	$63.04	10.3%

Totals may not add due to rounding.

BIO will continue its commitment to education, training, and increasing diversity while emphasizing 21st Century Biology within all of its divisions and subactivities. The FY 2009 Request will slightly increase award size and success rates. It will also continue to focus on interdisciplinary research and interagency partnerships and activities, with special attention given to broadening participation at all levels.

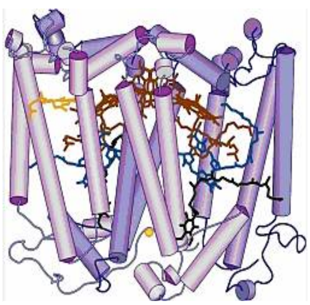
Recent Research Highlights

► **Northern Forests Less Effective Than Tropical Forests in Reducing Global Warming:** To help determine what happens to carbon emitted as carbon dioxide from industrial sources, researchers analyzed flasks of air that had been collected for decades by research aircraft over various global locations. Results show that computer models of carbon had overestimated the amount of carbon absorbed by northern forests and the amount of carbon released by tropical ecosystems, and underestimated net carbon emissions from northern forests. This means that northern forests are doing significantly less and tropical forests are doing significantly more to offset global warming than predicted by computer models. Computer models were incorrect because they had relied on ground-level measurements and so had failed to accurately account for the vertical movement of carbon dioxide in the atmosphere. (DEB)



Northern forests play a smaller role in offsetting global warming than previously thought. *Credit: NCAR.*

► **Scientists Offer New View of Photosynthesis:** To help determine how plants efficiently scavenge nearly every photon of available light during photosynthesis, researchers studied the reaction center of a photosynthetic bacterium, where light energy is funneled into specialized chlorophyll-binding proteins. By using an ultra-fast laser that acts like a high-speed motion picture camera capturing lightning-fast reactions, the researchers analyzed the orchestrated movements of proteins that occur on a timescale of a millionth of a millionth of a second. This analysis revealed that during photosynthesis, proteins move in the reaction center in ways that promote electron transfer and maximize the harnessing of light energy even when conditions are not optimal. Such insights may support the development of organic solar cells that use the same chemistry as living organisms to harvest the sun's energy. (MCB)

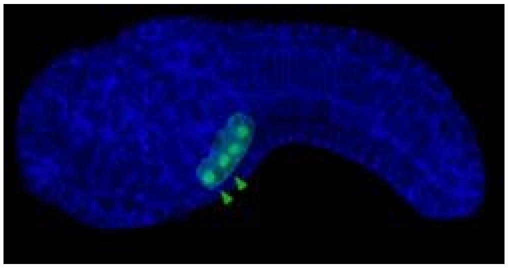


Biologists have discovered that a split-second, highly orchestrated process drives photosynthesis. *Credit: ASU.*

► **Biologists Develop Large Gene Dataset for Rice Plant:** The largest gene sequence database ever amassed for a plant species was created for rice. These data will advance our understanding of how genes work in rice, which is the major food crop for much of the world's population. Researchers will also use the database to examine the role of small ribonucleic acids (small RNAs) in gene expression in all plants. Though once considered biologically unimportant, small RNAs are now known to play important roles in gene regulation. In this study, advanced gene sequencing technologies and high-powered computer technologies were used to examine both normal gene expression as well as small RNAs. The dataset was based on gene sequences representing nearly 47 million mRNA molecules and three million small RNAs. (PGR)

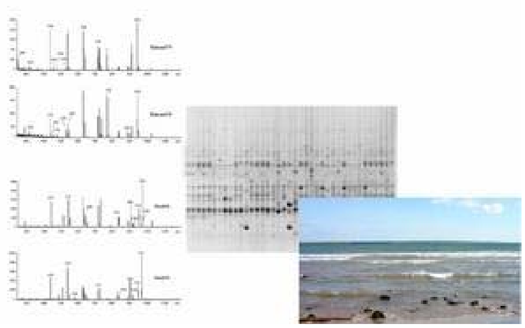
Plant biologists have reported a new understanding of how genes work in rice. *Credit: Fangming Xie, IRRI.*

► **Heart to Heart: Evolution of the multi-chambered heart:** Researchers found that changing the activity of a single gene, named *ets1/2*, doubled the number of cells in the developing sea squirt heart, which is single-chambered. But instead of leading to a heart that was simply twice as big, this doubling led to the formation of a functional two-chambered heart. These results show that small genetic changes can generate new, more complex organs and structures. They provide clues about how the heart evolved from an ancestral one-chambered organ into the multi-chambered structure present today in humans and other vertebrates. They also demonstrate that studies of a single gene, in a non-mammalian species like the sea squirt, can improve our understanding of human heart cells and congenital heart defects. (IOS)



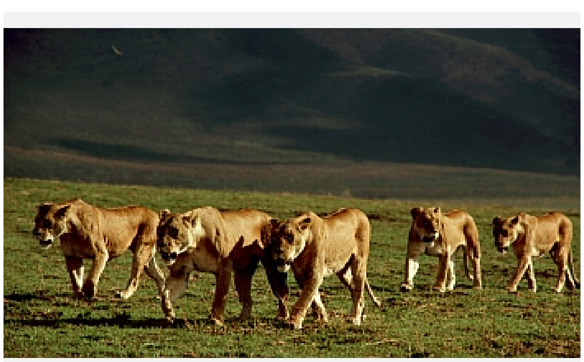
A transgenic Ciona embryo with expanded *ets* gene activity makes twice as many heart precursors. Normally only the anterior two cells (arrowheads) will form the heart. Two additional heart precursors are formed when *ets* gene activity is expanded and this can result in an additional heart chamber in the adult. *Credit: This research was conducted by Brad Davidson in the laboratory of Michael Levine.*

► **A New Way of Identifying Bacteria in the Environment:** NSF funding enabled researchers at the University of Wisconsin to develop a new method of identifying strains of bacteria in environmental samples, such as lake or irrigation water. They invented a special type of mass spectrometer to distinguish between bacterial strains based on analysis of proteins in the cells. This method of protein profiling is more rapid and less costly than DNA fingerprinting, the traditional means of strain identification. Faster identification of bacterial strains allows for a quicker response to possible health threats, such as the contamination of California spinach with a dangerous *E. coli* strain that sickened several hundred people in 2006. (DBI)



Protein fingerprint from mass spectrometer (left), DNA fingerprint (center), recreational waters in Door County, Wisconsin (right). *Credit: University of Wisconsin at Oshkosh.*

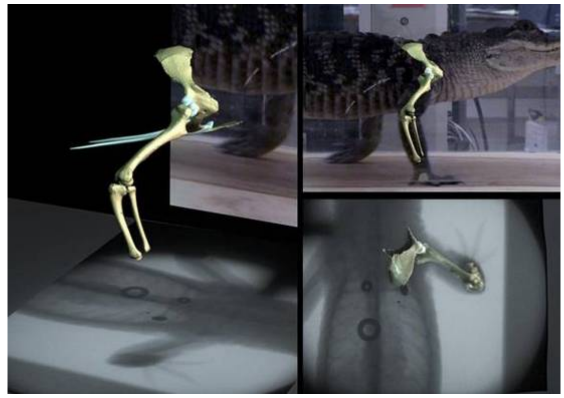
► **Forming Groups Stabilizes Populations of Predators and Prey:** Breaking with 80 years of ecological theory, scientists have found that the best way to spot a sustainable relationship between social predators and prey is to count not the animals, but the groups they form. Social grouping was more strongly correlated with the long-term stability, or sustainability, of the Serengeti ecosystem suggesting that even if an ecosystem has lots of carnivores and their herbivores, the two populations may be in trouble if the animals are social but cannot readily form groups. Ecologists have long modeled interactions between predators and prey by taking head counts of each species, ignoring the fact that many predators and their prey both form social groups. But the number and distribution of groups, rather than individuals, is most important in determining how often and how long the two species will interact. Results suggest that road building and other human disruptions that spread



Scientists have found that being social and forming groups is a protection against prey extinction. *Credit: Craig Packer, University of Minnesota.*

wildlife out and keep them from grouping have important implications for sustainably managing large ecosystems like North American national parks. (DEB)

► **X-Ray vision: Science Fiction to Science Fact:** Imagine being able to see inside an animal and watch its bones move. Imagine if scientists had a better way to study moving skeletons and doctors had a better way to diagnose and study skeletal injuries. This capability may no longer be out of reach. Researchers at Brown University have developed a method of clearly observing the movement of skeletons of living animals. Using a novel technique called scientific rotoscoping, the researchers simultaneously record standard video of moving animals and X-ray images of their moving skeletons. Seeing the movement of bones from shoulder joints to wrists and legs, which this technology provides, has many potential applications. It could transform both applied work and basic research in comparative biology and medicine. It could allow for clearly observing bone movements, testing theories about the mechanics of animal locomotion, and planning orthopedic surgeries, diagnosing injuries, and observing the effectiveness of different clinical treatment techniques. (IOS)



Scientific Rotoscoping of a walking alligator (left). 3-D computer models of shoulder and forelimb bones are aligned to X-ray (lower right) and standard (upper right) video frames. The resulting animations and data accurately capture motion at each joint. *Credit: David Baier.*

► **MorphoBank: New Software to Facilitate Virtual Collaborations:** Researchers designed a new Web application, called MorphoBank, which is revolutionizing morphological biology, the branch of biology that addresses the form and structure of organisms. MorphoBank is a secure virtual workspace that provides powerful visual software for comparing the morphology of organisms. This application currently houses more than 3,000 images that range from insects to fossils of humans, and its capabilities include zoom and label features. By providing these features, MorphoBank supports more archiving than was previously possible and enables scientists to collaborate across large distances to reach agreement on the descriptions and categorizations of biological specimens, which is required to classify organisms. Applications such as MorphoBank are becoming increasingly important as large international collaborative efforts become more common. (DBI)

Screen shot from MorphoBank 2.0 showing image zoom and labeling capabilities. *Credit: The MorphoBank Project.*

Other Performance Indicators

The tables below show the number of people benefiting from BIO funding, along with trends in the award size, duration, and number of awards.

Number of People Involved in BIO Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	4,106	4,010	4,290
Other Professionals	1,559	1,520	1,630
Postdoctorates	1,267	1,240	1,330
Graduate Students	2,641	2,580	2,760
Undergraduate Students	3,365	3,285	3,520
K-12 Teachers	58	58	58
Total Number of People	12,996	12,693	13,588

BIO Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	1,303	1,250	1,310
Funding Rate	19%	18%	19%
Statistics for Research Grants:			
Number of Research Grants	970	930	975
Funding Rate	17%	15%	16%
Median Annualized Award Size	$141,929	$149,000	$156,500
Average Annualized Award Size	$182,246	$191,000	$200,600
Average Award Duration, in years	3	3	3

Biological Science Directorate Reorganization

In FY 2009, the Biological Sciences Directorate is requesting a realignment of two activities. The first will move Plant Genome Research (PGR) as a new program line under the Integrative Organismal Systems (IOS) subactivity. The future activities of PGR will be facilitated by the pioneering systems biology approaches and research projects emphasized and supported within IOS, and will provide an integrated approach to funding plant genome research and the plant sciences. The second move will transfer management and oversight of NEON to the Emerging Frontiers (EF) subactivity. This move will ensure strong management oversight and integrate NEON into the transformational and frontier science supported by this subactivity at a critical time in its development.

BIO Reorganization Crosswalk – FY 2009

(Dollars in Millions)

New Structure	Current Structure						Total New Structure
	MCB	IOS	DEB	DBI	EF	PGR	
Molecular and Cellular Biosciences (MCB)	$126.10						$126.10
Integrative Organismal Systems (IOS)		$115.05				$101.22	216.27
Research Project Support		115.05					115.05
Plant Genome Research Program						101.22	101.22
Environmental Biology (DEB)			$0.64				125.64
Biological Infrastructure (DBI)				$86.99			86.99
Emerging Frontiers (EF)				10.00	$110.06		120.06
Research Project Support					94.06		94.06
National Ecological Network Observatory (NEON)				10.00	16.00		26.00
Plant Genome Research Program (PGR)						0.00	0.00
Total Current Structure	$126.10	$115.05	$125.64	$96.99	$110.06	$101.22	$675.06

Restructuring of IOS/PGR Organization:

The Plant Genome Research (PGR) subactivity was initiated in FY 1998 as part of the National Plant Genome Initiative (NPGI). PGR is part of BIO's Plant Biology portfolio that also includes the Plant Cyberinfrastructure Collaborative established in FY 2008 and funded through EF, the 2010 program supported separately from PGR by all the BIO divisions, and additional projects funded by core programs via unsolicited proposals. These investments have established the U.S. as the world leader in fundamental research in plant biology, transformed plant biology into a 21st century science, revitalized plant sciences at U.S. colleges and universities, attracted a new generation of students to plant biology research, and catalyzed large multinational collaborative plant genome research projects. The FY 2009 budget will take the next steps to ensure US preeminence in plant biology research.

National and international reviews of the future of plant science research make the point that the future improvement of economically important crops will come from integrating functional genomics, systems biology, and novel genes from a diversity of plant species. To achieve this vision in FY 2009 PGR will become a distinct program element in the Division of Integrative Organismal Systems (IOS). In FY 2008 the IOS subactivity was realigned to focus on understanding emergent properties of living systems such as complexity, sustainability, resilience, robustness, and adaptability. Understanding these properties translates to practical plant characters like improved yield, drought tolerance, and adaptation to a changing climate by integrating genetic, developmental, physiological, and structural systems. Placing PGR in the IOS research activity is a way to readily translate basic knowledge about how plants function as systems into the improvement of economically important crops.

In FY 2009, the restructured subactivity will have two distinct program elements with separate budgets: research project support aligned with established IOS programs and the plant genome research program. While separate support will be maintained for each, there will be an increased emphasis on interaction and integration of the science from both research communities to the benefit of both.

Restructuring of DBI/EF Subactivities:

The National Ecological Observatory Network (NEON) was funded as a new start MREFC project in FY 2007. Restructuring the NEON project oversight from the Biological Infrastructure subactivity to the Emerging Frontiers subactivity will allow for stronger management and oversight of the project at a critical time in its development. In addition, the emerging frontier science expected as a result of the NEON facility will complement other EF programs.

MOLECULAR AND CELLULAR BIOSCIENCES $126,100,000

The FY 2009 Budget Request for the Division of Molecular and Cellular Biosciences (MCB) is $126.10 million, an increase of $13.59 million, or 12.1 percent, over the FY 2008 Estimate of $112.51 million.

Molecular and Cellular Biosciences Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Molecular and Cellular Biology	**$111.50**	**$112.51**	**$126.10**	**$13.59**	**12.1%**
Major Components:					
Research & Education Projects	111.50	112.51	126.10	13.59	12.1%

About MCB:

The Molecular and Cellular Biosciences Division supports research aimed at illuminating the molecular underpinnings and defining the indispensable properties of complex living systems. Creative ideas and insights from MCB-supported investigators transform our understanding of the natural world and the molecular basis for the emergence of life on Earth. This research will lead to a better understanding of form and function in multi-scale, complex, biological systems, and of the dynamic interactions of living systems with the physical world. These advances contribute to our economy through discoveries pointing to new products and processes with applications in biotechnology, nanotechnology, and agriculture and contribute to our ability to detect and defend against biological threats.

Key biological questions in MCB-supported projects address the fundamental principles that determine the structural, functional, and dynamic properties of the complex molecular machinery involved in genetic, cellular, and signaling processes in all organisms, with a particular emphasis on microbial and plant systems. Answering such major biological questions increasingly requires the tools of genomics, the physical sciences, mathematics, computer and information science, and engineering, as well as integration of theoretical and experimental approaches.

MCB continues to forge partnerships to support research at the interfaces of these complementary disciplines, to introduce new analytical and conceptual tools for biological research, and to provide unique education and training opportunities for the next generation of researchers, scientific educators, and scientifically literate citizens. Leading edge cyberinfrastructure is indispensable in MCB-supported research for capturing, storing, manipulating, and analyzing large volumes of diverse data.

MCB supports multidisciplinary research through three scientifically-focused clusters. Within the **Biomolecular Systems** cluster, the use of cutting-edge technologies is a priority to integrate theoretical and experimental approaches to study the dynamic properties of biological molecules and their complexes (paradigms for nanomachines). Nanoscale studies of the structure, function, and assembly of cellular elements are a priority for the **Cellular Systems** cluster. The **Genes and Genome Systems** cluster emphasizes genome dynamics, genetic circuitry, and genetic mechanisms used by living systems to express and regulate the information encoded in the genome.

In general, 34 percent of the MCB portfolio is available for new research grants. The remaining 66 percent is used primarily to fund continuing grants made in previous years.

MCB priorities for FY 2009:

MCB will place the highest priority on innovative, creative, and potentially transformative projects that advance our understanding of the molecular underpinnings of complex living systems. The transfer of energy and information among a heterogeneous group of individual units (molecules, cells, organisms, and/or populations) is critical for orchestrating many of the unique properties of life such as robustness and resilience. Furthermore, it is now realized that the DNA sequence encodes far more information than what is used to determine protein sequences, and that biomolecules contain much more heritable information than what is encoded in the sequence of nucleotides. Research that deepens our understanding of the networks and interactions that govern the flow of energy and information in living systems, and the myriad ways in which information is encoded within biomolecules, cells, and organisms, will be highlighted.

Building connections with the physical sciences is instrumental in enhancing the theoretical, computational, mathematical, and simulation approaches that are critical for studies of biological complexity at the molecular and cellular level. Thus, MCB will also give priority to opportunities that benefit research at the interface and in the intersection between the physical sciences and biology, as investments in interdisciplinary research are likely to lead to transformative breakthroughs in these critical areas.

MCB will continue to place a high priority on efforts to integrate research and education and to broaden participation by infusing these values throughout all of the core activities, and also by supporting awards made through the NSF-wide CAREER and Research at Undergraduate Institutions programs.

Changes from FY 2008:

Guided by the priorities described above, research and education supported in the **MCB core** will increase by $13.59 million. Following a reduction in research awards (-5%) and decrease of 12% in success rates (from 17% to 15%) in FY 2008, this increase will focus on improving average award sizes to enable transformative research and provide for the integration of research and education—endeavors that have significantly increased the cost of research.

- Emphasis areas of research (+11.59M): Projects that incorporate metagenomics, theoretical and mathematical modeling, synthetic biology, small RNA biology, protein folding and modifications, and the role of the intracellular environment in the dynamic structure and function of complex biomolecules will be emphasized, as will those that address critical questions in microbial and plant systems.
- Interface of the Physical and Life Sciences (+2.0M): The new Life in Transition activity will contribute to advancing our understanding of the origin of life through synthetic biology research, and the flow of energy through natural systems. MCB-supported research at the interface of the physical sciences is well-positioned to address how the building blocks and heritable units of life, and life processes, evolved under the physical and chemical conditions that existed on the early, prebiotic Earth.

INTEGRATIVE ORGANISMAL SYSTEMS $216,270,000

The FY 2009 Budget Request for the Division of Integrative Organismal Systems (IOS) is $216.27 million, an increase of $16.41 million, or 8.2 percent, over the FY 2008 Estimate of $199.86 million.

Integrative Organismal Systems Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Integrative Organismal Systems	**$202.31**	**$199.86**	**$216.27**	**$16.41**	**8.2%**
IOS Project Support	$101.50	$101.99	$115.05	$13.06	12.8%
Plant Genome Research Program	100.81	97.87	101.22	3.36	3.4%

About IOS:

Biology, in the context of the organism, addresses questions that cannot be answered by focusing on the extremes of molecules or ecosystems. Innovations in genomics, molecular biology, and computer science are now enabling advancement of the frontiers of knowledge on an array of complex questions. The goal of IOS-funded research is to predict why organisms are structured the way they are and function as they do with a particular emphasis on emergent properties of organisms (including complexity, robustness, communication, cooperation, and adaptability). Understanding these emergent systems properties of organisms requires integrative, interdisciplinary approaches and innovative integration of information across levels of analysis and stages of development, across phyla, environments, and evolutionary time. It can also require computational techniques and interdisciplinary perspectives from other areas of biology, the physical sciences, mathematics, engineering, social sciences, and computer science.

Advancing understanding of living systems cannot be achieved merely by enumerating and describing their individual components. IOS researchers are now advancing the frontier of understanding complex, dynamic organismal systems in their natural environments by building on investments in genome sequencing and projects that have accumulated in-depth knowledge of the molecular nature of biological systems. New knowledge and insights gained from plant genomics, for example, are leading to unexpected discoveries and conceptual advances in our understanding of the biology of plants.

Innovative studies offer potential solutions to many critical national problems such as energy production, carbon sequestration, improved crop yields, environmental clean up, improved diagnosis and treatment of disease, as well as better protection of people from environmental hazards. For example, organisms could be modified to serve as sensitive detectors for dangerous pathogens and toxins, or to create novel materials, catalysts, and drugs. Finally, advancing our understanding of how emergent properties arise in organisms may ultimately lead to a paradigm shift in the design, engineering, and production of biomimetic materials and machines, such as highly maneuverable, advanced aircraft.

The IOS portfolio has two interactive and integrative programmatic areas of support:

- **IOS Project Support** includes support for studies of behavioral, developmental, neural, physiological, and structural systems and how they are integrated in living organisms.
- **The Plant Genome Research Program (PGR)** supports genome-enabled plant biology research that takes full advantage of cyberinfrastructure and the latest systems biology approaches in studies using model systems and plants and plant processes of economic importance.

In general, 40 percent of the IOS portfolio is available for new research grants. The remaining 60 percent is used primarily to fund continuing grants made in previous years.

IOS Priorities for FY 2009:

IOS will place highest priority on highly creative, integrative, and transformative studies that lead to a deeper understanding of the emergent properties of organisms. Studies that cross previously disparate scientific areas and that cross scales of organization from molecules to ecosystems involving a variety of levels of analysis will be highlighted.

Changes from FY 2008:

Guided by the priorities described above, research and education supported in the **IOS** will increase by $16.41 million -- +$3.36 M for Plant Genome Research program and +$13.06 M for IOS project support. Following a reduction in research awards (-5%) and decrease of 12% in success rates (from 17% to 15%) in FY 2008, this increase will focus on improving average award sizes to enable transformative research and provide for the integration of research and education—endeavors that have significantly increased the cost of research. It will also focus on returning the Plant Genome Research program to FY 2007 levels of funding.

- The **Plant Genome Research Program** (+$3.36 million), building on the ten years of investment in this program as part of the National Plant Genome Initiative (NPGI), will provide continued support for genome-enabled plant biology research, including continued support of collaborations between U.S. scientists and scientists in developing countries. PGR forms part of BIO's Plant Biology portfolio that also includes: the Plant Cyberinfrastructure Collaborative established in FY 2008 and funded through EF, the 2010 program supported separately from PGR by all the BIO divisions, and additional projects funded by core programs via unsolicited proposals.

- Disciplinary and interdisciplinary research in the **IOS core** will increase by $13.06 million to support innovative studies to provide a deeper understanding of the properties emerging from the interactions of the myriad of processes and structures of living systems. IOS will continue to give the highest priority to projects that integrate research and education while broadening participation. Included in this increase is support for:
  - Applying neuroscience theory and concepts is at the heart of the new **Adaptive Systems Technology** activity (+$3.49). Knowledge of the structure and function of nervous systems and the mechanisms underlying behavior provides a blueprint for advancing transformational research with the aim of discovering innovative design principles and new technologies based on nature's varied solutions for survival.
  - Investments in the new **Life in Transition** activity (+$2.0) will focus on understanding bio-centered energy technology systems and their potential utility. IOS will invest in projects aimed at discovering the mechanisms and principles of resilience and sustainability that enable some life forms to survive, adapt to, and transform their environment.

ENVIRONMENTAL BIOLOGY $125,640,000

The FY 2009 Budget Request for the Division of Environmental Biology (DEB) is $125.64 million, an increase of $14.78 million, or 13.3 percent, over the FY 2008 Estimate of $110.86 million.

Environmental Biology Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Environmental Biology	**$109.60**	**$110.86**	**$125.64**	**$14.78**	**13.3%**
Major Components:					
Research & Education Projects	109.60	110.86	125.64	14.78	13.3%

About DEB:

Fundamental research on complex ecological and evolutionary dynamics is crucial to maintaining a vital economy while insuring a healthy environment. It improves our ability to forecast and mitigate environmental change and illuminates options for sustaining and improving ecological systems and related goods and services. The Division of Environmental Biology supports catalytic and transformative research into the diversity of life on earth to discover its origins and evolutionary history and to understand its dynamics within ecological systems at many scales. Biodiversity and evolutionary studies concern all life on earth, including the oceans, while ecological studies emphasize terrestrial and aquatic (non-oceanic) ecosystems. Study systems include pristine as well as intensively managed habitats, including a network of long-term ecological research sites. DEB-funded research informs our ability to live sustainably on earth because ecological systems provide the goods and services upon which human health, wealth and welfare depend (e.g., clean water, food and fiber, crop pollination, disease control).

DEB is the primary source of federal research funding addressing fundamental questions in ecology and evolution, including how terrestrial and aquatic environments fit into global carbon cycling. DEB will continue to foster synthesis and education in environmental biology while promoting full participation of all groups. Scientific foci in DEB address the processes of evolution; describe the genealogical relationships of all life; elucidate the spatial and temporal dynamics of species interactions that govern the assembly of functional communities; and determine the flux of energy and materials through ecosystems. This theoretical and empirical research in ecology, evolution and biodiversity is continually transformed as it incorporates new tools from genomics, computer, and mathematical sciences. In turn, study of ecological and evolutionary dynamics has inspired breakthroughs in mathematics, such as chaos theory.

Biodiversity research is time-critical due to extinctions and global homogenization of flora and fauna. This research serves sister fields such as physiology, neuroscience, conservation, ecological restoration, and disease ecology. Phylogenetic approaches provide a framework for predicting genetic potential and risk and aid in the discovery of economically-important processes and products.

DEB supports the Long-Term Ecological Research (LTER) program, a network of 26 research sites representative of the range of natural, agricultural, and urban ecosystems in the U.S. A Network Office coordinates cross-site communication, education, outreach, and international activities, while promoting synthesis via an open access data policy. All LTER projects share common research themes that facilitate multi-site and interdisciplinary activities. A decadal planning exercise has highlighted opportunities for leveraging the existing network to further our understanding of integrated natural and social systems.

In general, 48 percent of the DEB portfolio is available for new research grants. The remaining 52 percent is used primarily to fund continuing grants made in previous years.

DEB priorities for FY 2009:

- Characterizing the diversity of life on earth continues to be a key, time-sensitive objective. DEB will continue to support biodiversity research with increased emphasis on resolving uncertainties regarding the ancestry of microbial life forms. The explosion of genomics-level information about living organisms has opened up new avenues of inquiry that relate the adaptability and dynamics of populations to their genetic makeup. Foci include: how populations respond to climate and other anthropogenic forcing; how evolutionary processes relate to ecological patterns; and discovering the properties of resilience and robustness that enable some life forms to survive, adapt and often transform their environment. Freshwater and terrestrial ecosystems are major components of earth's global carbon cycle and thereby enter strongly into future climate scenarios. DEB will continue to play a major role in funding research to reduce uncertainties in global climate projections, as well as to improve understanding of the adaptability and malleability of these systems. Dynamic interactions of coupled social and natural systems are another high research priority.

- DEB will continue to support integrated education and research experiences that involve experiential, hands-on exposure to science. Students and teachers in these programs will contribute to a diverse citizenry well-prepared to understand and apply information about the biological world in their daily lives. DEB supports CAREER grants, Doctoral Dissertation Improvement Grants, Research Experiences for Teachers and Research Experiences for Undergraduates. It funds the LTER Schoolyard Science activity.

Changes from FY 2008:

Guided by the priorities listed above, disciplinary and interdisciplinary research in the DEB core will increase by $14.78 million. Following a reduction in research awards (-5%) and decrease of 12% in success rates (from 17% to 15%) in FY 2008, this increase will focus on improving average award sizes to enable transformative research and provide for the integration of research and education—endeavors that have significantly increased the cost of research. Included in this increase is support for:

- Interface of the Physical and Life Sciences (+$1.0M): DEB investments in the **Life in Transition** activity will focus on the role of the living world in adapting to and shaping a changing Earth, particularly focusing on fundamental questions at the junction of the life and physical sciences.

- **Dynamics of Water Processes in the Environment** (+$4.21M): This new NSF activity will be supported within DEB core activities. It will address society's need for improved knowledge to face conflicting demands on limited freshwater resources. Research in DEB is fundamental to our understanding of the vulnerability and resilience of freshwater systems to climate and environmental change. Research will focus on complex system properties such as thresholds and tipping points, maintenance of freshwater biodiversity, hydrological drivers of aquatic ecological systems, and effects of climate change on freshwater species.

BIOLOGICAL INFRASTRUCTURE $86,990,000

The FY 2009 Budget Request for the Division of Biological Infrastructure (DBI) is $86.99 million, an increase of $50,000 or 0.1 percent, over the FY 2008 Estimate of $86.94 million.

Biological Infrastructure Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Biological Infrastructure	**$80.23**	**$86.94**	**$86.99**	**0.05**	**0.000575**
Research Resources	48.22	55.61	55.66	0.05	0.1%
Human Resources	32.01	31.33	31.33	-	-

About DBI:

DBI's responsibility is to provide innovative scientific infrastructure that empowers the biological research community to advance all sub-disciplines of biology. The division funds a number of infrastructure projects that are large, inter- and multi-disciplinary. Through DBI, BIO has been able to support projects responding to the ACI priority for "Federal investment in the tools of science—facilities and instruments that enable discovery and development—particularly unique, expensive, or large-scale tools beyond the means of a single organization." DBI supports the development of a range of infrastructures, including instrumentation, informatics resources, biological collections, field stations and marine laboratories - elements critical to the operation and success of the larger biological enterprise. DBI is uniquely positioned to contribute to the increased need for interdisciplinary training for biologists in math, physical, and information sciences and greater opportunities for undergraduate research.

DBI is organized into two clusters. The **Research Resources** cluster supports development of research tools and resources The **Human Resources** cluster focuses on integration of research and education, and works closely with the Education and Human Resources Directorate.

The DBI portfolio includes fellowships, instrumentation, infrastructure improvements, and research grants. Approximately 37% is available for all new awards each year while approximately 15% of the DBI portfolio is available for new research grants. The remainder is distributed through grants for various DBI priorities and continuing funding for grants made in previous years.

DBI Priorities for FY 2009:

Research Resources

- Cyberinfrastructure ($) has been an integral part of all DBI activities and will continue to be a high priority for FY 2009. Biological Informatics supports the design, development, implementation, and use of information resources and cyberinfrastructure tools needed across biology for analysis and integration of data, informatics tools to provide the power to mine all available information and data/biological research resources to be utilized for new insights and discoveries.
- Instrumentation Resources ($) provides access to the latest instrumentation with new capabilities; and the development of new instruments for transformative research in areas such as Life in Transition. Supporting the ACI in funding the development of biological instrumentation ensures that the next generation of scientists and engineers can maintain our competitive edge. Improving field research

facilities increases America's capability for transformative research, contributes to NEON, and supports Life in Transition and the Dynamics of Water Processes in the Environment activities through access to different environments. BIO's participation in Major Research Instrumentation is managed within this subactivity.

- The Adaptive Systems Technology area will be supported by funding collaborative teams of biologists, engineers, and physical scientists to develop the next generation of adaptive tools based on biological models.
- Improvements to natural history collections archived at museums, botanical gardens, field stations, and academic institutions that are widely used for biological research and education ensures that the nation's scientific collections will continue to play a major role in the analysis of environmental change, national security, and economic development and emphasizes new strategies to further collections research. Support for repositories of live research organisms, genetic stocks, seeds, cell lines, and DNA clones that are associated with whole organisms in a collection provides access for researchers to these tools necessary for interdisciplinary research.

Human Resources

Broadening participation and integration of research and education are priorities. To provide scientists at all stages of their careers with a conceptual framework that embraces new technologies, techniques, and tools and applies this infrastructure broadly across the sciences is critical for human resource development.

- Provide year-round research mentoring in Biology ($5.0 million) for undergraduate students, especially those from underrepresented groups to train a new generation of scientists open to new approaches across scientific boundaries.
- Support increasingly interdisciplinary Research Experiences for Undergraduates site awards through partnering with MPS, ENG, and SBE.
- Support postdoctoral fellowships with solicitations that allow flexibility to address emerging resource needs throughout biology and also focus on broadening participation.
- Increase the participation of individuals from groups underrepresented in the scientific enterprise, especially beginning investigators or those new to obtaining research support ($9.99M).
- This cluster manages BIO participation of the NSF-wide human resource activities including GK-12 ($1.14M), Advance ($2.50M) and IGERT ($6.50M).

Changes from FY 2008:

Guided by BIO priorities to sustain and enable core research, including support for the new Life in Transition activity, and to support NSF-wide activities for Adaptive Systems Technology and Dynamics for Water Processes in the Environment, all programs supported within the Biological Infrastructure subactivity will be significantly impacted. Programmatic evaluations will be continuing in FY 2009 to identify the research and human resource programs most effective and essential for advancing the frontiers of the biological sciences.

- Research Resources: In order to sustain funding levels and enable research through appropriate award sizes, some programs were deferred in FY 2008 and will be put on alternate year funding cycles, including support for field stations and marine laboratories; instrumentation; biological collections; and informatics resources.
- Human Resources: In order to focus support for programs where BIO can make a difference, particular attention will be given to evaluating the effectiveness of programs in broadening participation and mentoring in biology.

EMERGING FRONTIERS $120,890,000

The FY 2009 Budget Request for the Emerging Frontiers (EF) Subactivity is $120.89 million, an increase of $19.04 million, or 18.7 percent, over the FY 2008 Estimate of $101.85 million.

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Emerging Frontiers	**$104.90**	**$101.85**	**$120.06**	**$18.21**	**17.9%**
Major Components:					
Research & Education Projects	78.40	58.29	66.84	8.55	14.7%
Centers Programs					
National Evolutionary Synthesis Center	2.99	2.89	2.29	-0.60	-20.7%
National Center for Ecological Analysis and Synthesis[1]	3.68	3.89	3.71	-0.18	-4.7%
Plant Science Cyberinfrastructure Collaborative	-	6.63	9.11	2.48	37.4%
Center for the Environmental Implications of Nanotechnology (CEIN)	-	3.00	3.05	0.05	1.7%
Center for Research at the Interface of the Mathematical Mathematical and Biological Sciences (CIMBS)	-		3.10	3.10	N/A
Center for Behavioral Neuroscience[2]	3.85	3.15	1.96	-1.19	-37.8%
Center for Microbial Oceanography	4.00	4.00	4.00	-	-
Facilities					
National Ecological Observatories Network	11.98	20.00	26.00	6.00	30.0%

About EF:

Emerging Frontiers supports innovative research, education, and networking activities that are built upon and integrate advances in disciplinary research. EF encourages synergy among disciplines using project, network, center, and infrastructure grants that cross disciplinary boundaries.

In general, 50 percent of the EF portfolio is available for new research grants. The remaining 50 percent is used primarily to fund continuing grants made in previous years.

EF priorities for FY 2009:

Interdisciplinary Research: Support continues for multidisciplinary teams to address major biological and transdisciplinary questions through the Theoretical Advances in Biology, Assembling the Tree of Life, and Coupled Natural and Human Systems programs. EF supports an integrated portfolio of microbial activities ranging from genomics to the ecology of infectious disease. Being inherently interdisciplinary, Dynamics of Water Processes in the Environment and Life in Transition are also supported by EF.

Centers conduct long-term scientific research, explore more effective ways to educate students, partner with industry and develop mechanisms to ensure the timely transition of research and education advances of benefit to society. Centralization of all BIO centers in EF fosters collaboration and integration of research themes and facilitates the sharing of best practices. Enhanced or new centers in FY 2009 are:

- **Plant Science Cyberinfrastructure Collaborative:** Established in FY 2008, this center enables new conceptual advances by bringing together new computer, computational science, and cyberinfrastructure solutions and teams of plant biologists, computer and information scientists, and experts from other fields to address an evolving array of major questions in plant science.
- **Center for Environmental Implications of Nanotechnology:** Established in FY 2008, this center conducts multidisciplinary fundamental research on the interactions between nanoparticles and materials and the living world at all scales. Examples of topics being addressed include interactions of nanomaterials with cellular constituents, bioaccumulation, and the impacts of nanostructures dispersed in the environment on living organisms. Research on methods for nanoparticle detection is also supported.
- **Center for Research at the Interface of the Mathematical and Biological Sciences:** Being established in FY 2009, this center will conduct research and education at the interface of the mathematical and biological sciences. The Center will address national needs, particularly the modeling of infectious diseases of animals and plants, and will provide knowledge useful to policy makers, government agencies, and society.

National Ecological Observatory Network (NEON): As the first research tool designed to enable regional to continental scale ecological research, constructing NEON, now in its final design and development stage, remains the highest priority for BIO

Changes from FY 2008:

Guided by the priorities described above, research supported in EF will increase by $18.22 million. Enabling innovative research, education, networking, and facilities activities that integrate advances in the life sciences will be the focus of FY 2009 increases:

- Life in Transition (+$5.0 million): Funding will support research on the indispensable properties of living systems;
- Transformative research (+$1.2 million): Venture funding for transformative research will increase.
- Centers (+$3.66 million):
  - The Center for Research at the Interface of the Mathematical and Biological Sciences ($3.1 million), deferred in FY 2008, will be supported in FY 2009;
  - Support will be enhanced for the Plant Science Cyberinfrastructure Collaborative (+2.48 million) which is BIO's contribution to the CDI activity; and
  - Support will be enhanced for the Center for Environmental Implications of Nanotechnology (+$50,000).
  - Other centers have small out-year adjustments. (-$1.97 million)
- NEON (+$6.0 million): Support for NEON will increase by $6.0 million to complete pre-construction activities.

COMPUTER AND INFORMATION SCIENCE AND ENGINEERING $638,760,000

The FY 2009 Budget Request for the Computer and Information Science and Engineering (CISE) Directorate is $638.76 million, an increase of $104.23 million, or 19.5 percent, over the FY 2008 Estimate of $534.53 million.

Computer and Information Science and Engineering Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate	
				Amount	Percent
Computing and Communication Foundations (CCF)	$122.76	$143.45	$180.01	$36.56	25.5%
Computer and Network Systems (CNS)	162.77	173.91	206.91	33.00	19.0%
Information and Intelligent Systems (IIS)	119.26	138.93	173.60	34.67	25.0%
Information Technology Research (ITR)	121.89	78.24	78.24	-	-
Total, CISE	$526.68	$534.53	$638.76	$104.23	19.5%

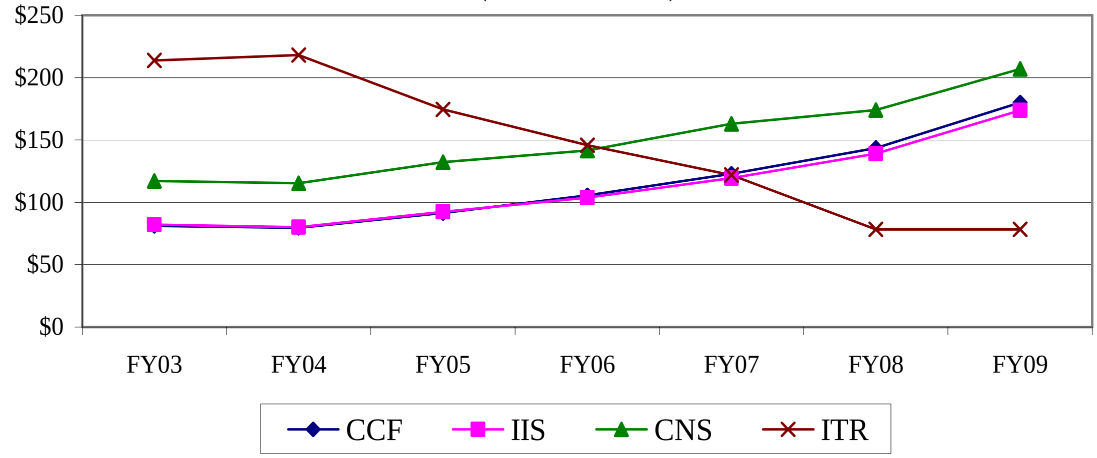
Totals may not add due to rounding.

CISE's mission is to enable the U.S. to uphold a position of world leadership in computer and information science and engineering; to promote understanding of the principles and uses of advanced computer, communications, and information systems in service to society; and to contribute to universal, transparent, and affordable participation in an information-based society. CISE supports ambitious, long-term research projects within and across the many sub-fields of computing, contributes to the education and training of computing professionals and, more broadly, informs the preparation of a U.S. workforce with computing competencies essential to success in an increasingly competitive, global market. CISE-supported fundamental research outcomes in computing and information technology inform the development and deployment of cyberinfrastructure supported by the agency in service to all fields of science and engineering.

The CISE Directorate is in a unique position to help realize the goals and objectives outlined in the President's American Competitiveness Initiative (ACI). CISE research and education outcomes are vital to the Nation's economic future in two important ways: they catalyze innovations in the information technology (IT) industry itself; and they stimulate innovation across a much wider range of economic sectors, including finance, healthcare, manufacturing, natural resources, transportation, and many others.

CISE Subactivity Funding

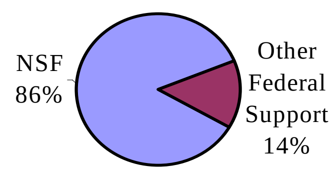
(Dollars in Millions)



RELEVANCE

NSF is the principal source of federal funding for university-based basic research in computer science, providing the vast majority – 86 percent – of total federal support in this area. In recent years, basic research investments in computing have provided unsurpassed value-added to the U.S. economy. As the President's Council of Advisors in Science and Technology (PCAST) recently referenced in their 2007 report, Leadership Under Challenge: IT R&D in a Competitive World, "*since 1995, networking and information technology industries have accounted for 25 percent of the Nation's economic growth, although they represent only 3 percent of the gross domestic product.*"

Federal Support for Basic Research in Computer Science at Academic Institutions



Essentially all practical applications of IT are based on ideas and concepts that emerged from basic research investments. These fundamental ideas and concepts have enabled innovative product and application developments that now permeate all areas of modern life. IT not only forms a sizeable portion of the economy in its own right, but drives discovery and innovation in many other areas, including advanced scientific research, healthcare, national and homeland security, organizational effectiveness, and governmental efficiency. Innovation in IT will remain an essential and vital force in productivity gains and economic growth in both the manufacturing and service sectors for many years to come, positioning NSF and CISE as central and essential actors in realizing the goals of the ACI.

The CISE Directorate continues to play a leadership role in the multi-agency subcommittee on Networking and Information Technology Research and Development (NITRD), which is co-chaired by the CISE Assistant Director. All projects supported by CISE investments, including all research, education, and cyberinfrastructure (computing research infrastructure), enrich the agency's NITRD portfolio. Consistent with the Administration's NITRD priority, in FY 2009 CISE will continue to explore the computing frontier, stimulating research advances in new algorithms, architectures, languages, and systems and in emerging models of computing – all enabling applications yet to be imagined. As computing systems provide richer functionalities and faster performance, as they become more ubiquitous and pervasive, and as user expectations of and demands on them increase, CISE investments in the fundamental research essential to systems design for properties such as privacy, security, reliability, and usability become increasingly important. The directorate's programs in cybersecurity, information security and privacy, distributed systems, and networking will produce research results that allow society to more fully exploit the potential benefits of an increasingly networked world. As we seek to better understand human intelligence and to use computing to enhance our quality of life, CISE will continue to invest in artificial intelligence, computer vision, graphics, machine learning, natural language processing, robotics, speech, search, information retrieval, and technologies for collaboration. CISE also will continue to strengthen the intellectual foundations of computing, supporting research in algorithms and theoretical computer science, cryptography, network and communication theory, and information theory. CISE contributions to the National Nanotechnology Initiative will permit exploratory and interdisciplinary work on novel quantum and bio-inspired device and systems technologies, as well as related programming models, languages and tools that promise to form the basis of the revolutionary new computing systems of the future.

As a result of the increasingly important role of computing in society, the number of new scientific opportunities and challenges presented by the field far exceeds the directorate's ability to fund them. While CISE has always received many more quality proposals than can be funded, proposal funding rates have declined dramatically since FY 2000 as a consequence of growth in the field. CISE was able to fund 32 percent of the proposals received in FY 2000; in FY 2009, it is projected that 22 percent will be supported.

NSF is the principal source of federal support for strengthening science, technology, engineering and mathematics (STEM) education across all levels and is uniquely positioned to lead the Nation in STEM education due to its focus on STEM education research. Two programs in particular, CISE Pathways to Revitalized Undergraduate Computing Education (CPATH) and Broadening Participation in Computing (BPC), increase American competitiveness in the global economy and support NSF's underlying strategy of integration of research and education. Further, they respond directly to PCAST 2007 recommendations that a nationwide effort be undertaken "*to strengthen networking and information technology education and training programs,*" with special attention "*paid to programs that educate future generations of workers involved in research and development, whose innovations and leadership will be critical to America's competitiveness in networking and information technology industries*."

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, CISE..………………………...……………………………….......................…$534.53

Computing and Communication Foundations (CCF) +$36.56

Increased funding will be used to further support Cyber-enabled Discovery and Innovation (CDI) research, emphasizing the application of computational thinking and algorithmic insights across all areas of science and engineering supported by NSF. In addition, CCF CDI investments will support research aimed at the engineering of software for complex systems along two complementary lines: establishing the scientific and engineering principles (e.g., inspired by complexity sciences) for developing software for tomorrow's complex cyber-based systems; and exploiting computational models underlying software systems to understand natural and physical systems. Through investments in Science and Engineering beyond Moore's Law (SEBML), CCF will explore revolutionary new computing paradigms, including bio-inspired and quantum computing. Finally, through increases in the CCF core programs, the division will call upon the academic research community to identify emerging transformative research opportunities that promise to revolutionize the field of computing.

Computer and Network Systems (CNS) +$33.00

Increased funding will be used to support CDI, with a focus on gaining better understanding of complex computer systems and networks and their emergent behavior. CNS will support research on new frameworks and models to understand and control emergent behavior in complex systems and networks, and on innovative ways to design and implement large-scale systems that exhibit robust and predictable behavior, particularly when operating under stress. Within CDI, CNS will also support transformative research which seeks to establish new scientific foundations and technologies for cyber-physical systems, an emerging class of physical and engineered systems whose operations are integrated, monitored and controlled by a computational core. In addition, CNS will support new CDI research directions in data-intensive applications, emphasizing powerful data-driven architectures and programming models that lead to natural, machine-independent, large-scale parallelism. Finally, CNS will increase support for the core areas of network science and engineering, computer systems, cybersecurity, education and workforce development, and research infrastructure.

Information and Intelligent Systems (IIS) +$34.67

Increased funding will be used to support CDI research, emphasizing new multidisciplinary research and education efforts that explore advanced data technologies, computing platforms, and collaborative environments in demanding scientific and engineering domains. Through Adaptive Systems Technology (AST) investments, IIS will support new research directions in which the robustness and adaptive capability of biological organisms inform the problems and approaches taken within CISE research. In addition, IIS will emphasize research on human-computer systems that explicitly expands our knowledge of how people interact with information technology, and how information technology can be designed that is explicitly informed by such knowledge. Finally, through increases in the IIS core programs, the division will support the most creative ideas generated by the IIS community to expand or enhance the impact of computing innovations in society.

Subtotal, Changes +$104.23

FY 2009 Request, CISE………………………………………………………………...………........$638.76

Summary of Major Changes in Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, CISE……………..…………..…………………………………….……….…$534.53

The CISE budget contributes directly to the goals of the ACI as well as to other Administration priorities including advanced networking and high-end computing. In FY 2009, the agency will build on core themes developed for CDI, highlighting new activities that hold significant promise for economic competitiveness and societal impact. Through joint investments with other directorates and offices, CISE researchers will explore and expand the use of computational abstractions to extract knowledge from digital data and to yield new insights in and understanding of a wide range of complex systems, including natural, built, and social systems. The computational concepts, methodologies, and tools developed with CDI investments promise to transform the conduct of research across all fields of science and engineering, and to result in a new wave of technological and societal innovations that will accelerate productivity growth and ensure American competitiveness for decades to come.

Discovery +$101.47

CISE will continue its investments in high-risk, high-return, fundamental research essential to innovation and economic competitiveness in IT. Just as research advances in IT have made unsurpassed contributions to the Nation's technological, economic, and security posture over the past decade, so future CISE research investments are designed to both deepen and broaden computing contributions to the Nation's competitive position.

- *Computing Fundamentals (+$78.35 million).* CISE will increase investment in core and emerging areas of computer and information science and engineering in research programs that emphasize transformative work. These areas include: the exploration of revolutionary computational models, languages, and tools, and hardware and software architectures that will serve as the primary catalysts for future innovations in information technology; transformative research on trustworthy software and networked systems that simultaneously explore the technological challenges as well as the equally important organizational, sociological, economic, legal, and psychological factors impeding progress in securing cyberspace; and exploration of human-centered computing and information and intelligent systems that promise value to a diverse range of individuals and to society at large. CISE will increasingly focus on programs and projects that identify plausible but high-risk opportunities with potential to result in significant, enduring impact in societal applications.

  As part of CISE's $113.50 million investment in cybersecurity research and education, the directorate will devote $30.0 million to research in usability (+$10.0 million); theoretical foundations (+$10.0 million); and privacy (+$10.0 million) to support the Comprehensive National Cybersecurity Initiative.

- *Cyber-enabled Discovery and Innovation (+$13.63 million).* To transform an abundance of digital data into new knowledge, CISE researchers will: explore new fundamental mathematical and computational abstractions to represent and manage data; participate in multidisciplinary projects that explore data mining, data federation, and extraction strategies in demanding science and engineering applications; and develop the underpinnings essential to the development of sophisticated data visualization and delivery tools. CISE will also invest in an emerging data-intensive computing paradigm where systems are designed, programmed, and operated to enable different forms of computation over massive data sets. To better understand complexity in built systems, CISE will emphasize investments in cyber-physical systems and software for complex systems. Finally, increased CISE investments will support the design, development, and assessment of IT-enabled, human-centered virtual organizations, advancing our ability to build and leverage the computational and organizational potential of virtual organizations as new modalities of scientific and engineering research and education and enterprise productivity enhancement.

- *Science and Engineering Beyond Moore's Law (+$6.0 million).* In SEBML, CISE researchers will explore radically new systems based on revolutionary technologies such as organic molecules, carbon nanotubes, optical switches, and superconductors, among others. New programming models will also be explored, along with the languages and compilers that support them. To optimize computing power, new algorithms that exploit highly parallel hardware and architecture characteristics in contemporary silicon-based technologies, such as multi-cores and communication and memory latencies, will also be examined.

- *Adaptive Systems Technology (+$3.49 million).* CISE will contribute $3.49 million to the NSF-wide Adaptive Systems Technology investment. CISE researchers will apply neuroscience concepts and principles in the investigation of the promise of intelligent distributed knowledge networks. Biological organisms whose self-assembly draws on a massively parallel fabrication process comprising large numbers of cells will serve as inspiration for CISE and other researchers exploring revolutionary new computing system architectures. And investigators will explore biomimetic organs and limbs that promise to augment human capabilities.

<u>Learning</u> +$0.37

Research Experiences for Undergraduates (+$200,000).
CISE will provide an additional $200,000 in support for students through the Research Experiences for Undergraduates (REU) Sites program.

Integrative Graduate Education and Research Traineeship (+$170,000).
CISE will provide an additional $170,000 in support for students through the Integrative Graduate Education and Research Traineeship (IGERT) program.

<u>Stewardship</u> +$2.39

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$104.23

FY 2009 Request, CISE……………………………..……………...…….……………………….............$638.76

NSF-WIDE INVESTMENTS

In FY 2009, CISE will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

CISE NSF-wide Investments

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Adaptive Systems Technology	-	-	$3.49	$3.49	N/A
Cyber-Enabled Discovery and Innovation	-	20.00	33.63	13.63	68.2%
Cyberinfrastructure	71.00	87.00	87.00	-	-
Human and Social Dynamics	5.00	2.00	-	-2.00	-100.0%
National Nanotechnology Initiative	12.89	12.22	11.00	-1.22	-10.0%
Networking and Information Technology R&D	526.69	534.53	638.76	104.23	19.5%
Science & Engineering Beyond Moore's Law	-	-	6.00	6.00	N/A

Adaptive Systems Technology (AST): A level of $3.49 million will support CISE research on the application of neuroscience concepts and principles in the investigation of the promise of intelligent distributed knowledge networks.

Cyber-enabled Discovery and Innovation (CDI): A level of $33.63 million will support CISE research in a variety of areas including new fundamental mathematical and computational abstractions, data mining, data federation, and extraction, and data visualization and delivery tools.

Cyberinfrastructure (CI): A level of $87.0 million will support research on computing systems and capabilities likely to become essential components in the cyberinfrastructure of the future. The challenges of scalability, security, reliability, and extensibility will be met with research and education activities in architecture, software, networking, theory, and new underlying technologies. The prominent role that digital data now play across science and engineering leads to systemic thinking about technologies that can support broad access to and use of scientific and engineering data in both educational contexts and in diverse uses in science and engineering research.

National Nanotechnology Initiative (NNI): A CISE investment of $11.0 million will support research in areas such as fundamental nanoscale phenomena and processes; nanoscale devices and systems; nanomanufacturing; and research facilities and instrumentation. Within CISE, these general categories encompass architecture, design, and fabrication of computer and information systems based on nanoelectronics, representation of quantum and classical information in nanostructures, and the national infrastructure needed to support such research.

Networking and Information Technology Research and Development (NITRD): CISE's entire request of $638.76 million is included in NITRD activities supporting fundamental research and related education in information technology and networking.

Science and Engineering beyond Moore's Law (SEBML): A level of $6.0 million will support CISE research on radically new systems based on revolutionary technologies, new programming models, and new algorithms that exploit highly parallel hardware and architecture characteristics in contemporary silicon-based technologies.

QUALITY

CISE identifies the highest quality research through the use of a competitive, merit-based review process. The percent of research funds that were allocated to projects that undergo external merit review was 95 percent in FY 2007, the last year for which complete data exist.

To ensure the highest quality in processing and recommending proposals for awards, CISE convenes Committees of Visitors (COVs), composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. COVs for all the CISE divisions are being planned for 2009.

CISE also receives advice from the Advisory Committee for Computer and Information Science and Engineering (CISEAC) on such issues as: mission, programs, and goals that best serve the scientific community; promotion of quality graduate and undergraduate education in the computer and information science and engineering sciences; and priority investment areas in computer and information science and engineering research. The CISEAC meets twice a year with members volunteering their time to serve on subcommittees for three additional days per year. Members from both academe and industry represent a cross section of the computer and information science and engineering field, with representatives from many different sub-disciplines within the field. The CISEAC includes a balanced representation of women, underrepresented minorities, and individuals from a range of geographic regions and institutions.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Computer and Information Science and Engineering

By Strategic Outcome Goal

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Discovery	$451.86	$463.23	$564.70	$101.47	21.9%
Learning	36.47	37.23	37.60	0.37	1.0%
Research Infrastructure	30.56	26.50	26.50	-	-
Stewardship	7.79	7.57	9.96	2.39	31.6%
Total, CISE	$526.68	$534.53	$638.76	$104.23	19.5%

Totals may not add due to rounding.

Recent Research Highlights

► **Digitizing a River in One Week:** In response to growing freshwater resource problems, scientists and engineers from the Center for Embedded Networked Sensing tested a sensor deployment campaign at the confluence of the Merced and San Joaquin Rivers. Their objective was to create a system for rapidly characterizing a complex river reach not only in terms of its bathymetry and floodplain, but also its flow and water quality parameters. Using a robotic sensing device, researchers scanned flow and water quality conditions across transects taken upstream, downstream, and within the confluence zone. Over a five-day period, nearly 300 cross-sectional distributions for flow velocity, temperature, pH, specific conductance, oxidation-reduction potential, dissolved oxygen, nitrate, and chlorophyll a were collected. Their work resulted in a three-dimensional map of the confluence zone, which, together with the transect data, will be used to create a multi-dimensional river model that scientists can use to analyze and forecast river conditions, and plan future large-scale experiments aimed at understanding and improving water quality. (CCF)

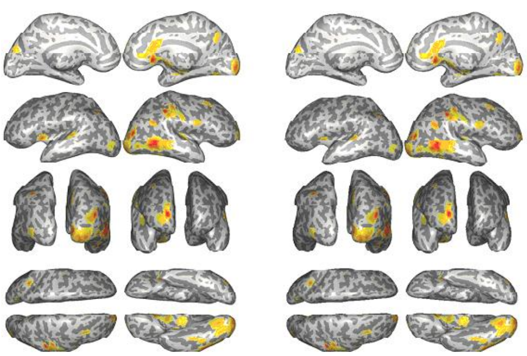
Scientists and engineers from the Center for Embedded Networked Sensing test a sensor deployment campaign approach at the confluence of the Merced and San Joaquin Rivers. *Credit: Jason Fisher, UC Merced.*

► **Light Fields and Computational Photography:** The explosive growth of digital photography, combined with the shrinking size of computers, has led to the birth of computational photography--techniques that extend the capabilities of digital photography. Light fields, a type of computational photography, means a collection of views of a scene, each taken from a slightly different position. Unlike conventional photography, light fields permit viewpoint and focus to be changed after the snapshot is taken. Researchers at the Stanford Computer Graphics Laboratory have built several devices for capturing light fields, including a "plenoptic camera," which is an ordinary camera with a microlens array inserted near the sensor. As computational photography moves into consumer products, it will change the face of photography forever. Since it is software-intensive, it may give the United States a competitive advantage in the photography marketplace. (CCF)

Photographs captured by Stanford Plenoptic Camera are digitally refocused after they are captured. The refocusing algorithm used in this camera was developed using NSF funding. Ren Ng (pictured above) won the 2007 ACM Doctoral Dissertation award for this research. *Credit: Ren Ng, Refocus Imaging.*

► **Improving Bridge Safety:** Researchers are working to improve bridge safety in Missouri as a model approach for the nation. The project involves equipping vulnerable bridges with sensors that monitor the bridge's structural condition and utilizing networks that can manage high-performance queries over wireless sensor networks. A particular research target is the Bill Emerson Memorial Bridge in Cape Girardeau, Missouri. It is a main crossing of the Mississippi River and lies within the New Madrid seismic zone. This bridge experiences a high volume of traffic and is a crucial component of the transportation network within the central US. With a sensor network embedded within the bridge's structural elements, the bridge can be continuously monitored for changes that may predict component failures. (CNS)

This picture shows the Bill Emerson Memorial Bridge in Cape Girardeau, Missouri, when it was under construction. It is the main crossing on the Mississippi River and lies in the New Madrid seismic zone. The real-time wireless sensor network system developed in this project is being deployed to insure the bridge's safety. *Credit: Missouri Department of Transportation.*



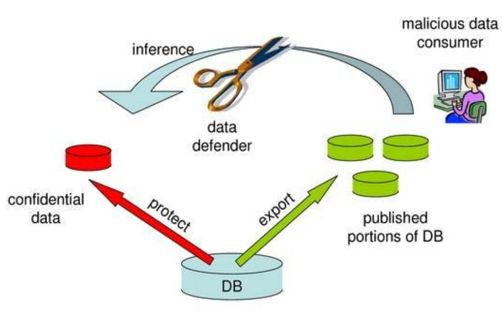
Reconstruction by a new method of the locations and extents of 70 simulated cortical electromagnetic source areas from only 1,000 simulated magnetic (MEG) time points at 273 scalp sensors (not shown). The left panel shows the mean activity levels of the simulated data on a human cortex. The right panel shows the mean activity levels of the estimated sources. Note the accuracy of the new method in capturing the locations and extents of the multiple cortical source areas. *Credit: Scott Makeig, UCSD.*

► **Brain Imaging in High Definition Mode:** The central problem of cognitive neuroscience is to identify, from non-invasive brain recordings, the patterns of distributed brain activity that support human cognition and behavior. Researchers at the University of California, San Diego, have made break-though progress in developing a new modeling method to identify the brain sources of signal patterns. The new method identifies not just the approximate points from which these signals emerge, but also the varying extents of the cortical areas whose electromagnetic field activities become locally synchronized, producing electrical and magnetic field changes that can be recorded from the scalp. The new method promises to make possible a new mode of high-definition dynamic brain imaging that, applied in particular to high-density EEG measurements, will be both much less expensive and much more flexible than existing dynamic brain imaging technologies, with unprecedented spatial and time/frequency resolution of complex patterns. (IIS)

An electronic-textile garment fabricated for context-awareness. The insets show sensors and processing elements, all of which are connected together by an on-fabric network. *Credit: Virginia Tech/Rick Griffiths/David Lehn/Joshua Edmison.*

► **E-Textile Garments:** Researchers at Virginia Tech are developing e-textile garments that can sense their own shapes and the wearer's activities. Continuously sensing the garment's shape makes it possible to determine the wearer's activity, whether the wearer is moving or perhaps falling. This enables the e-textile to adapt to the user's current situation. The software, sensors, and algorithms developed in this project permit the design of e-textiles that can adapt to a wide range of applications, without extensive tuning of the devices. In cooperation with the Intel Corporation, the researchers also have developed an e-textile rug that can track the position and motion of persons walking on the fabric. Applications for e-textile-based "wearable" computing include medicine, home health care, manufacturing and industrial processes, entertainment, and emergency response. One researcher, Dr. Thomas Martin, received the NSF Presidential Early Career Award for Scientists and Engineers (PECASE) for his leadership in the emerging area of e-textiles. (CNS)

► **Lower Energy Consumption for Data Centers:** Data centers like the ones built by Google, Microsoft, and Yahoo demand massive amounts of power. High power means higher costs, increased environmental impacts and limits on where the centers can be located. Research has been conducted on memory energy management, but few studies have focused on data servers where main memory is predominantly accessed by direct memory access (DMA) instead of processors. Researchers at the University of Illinois at Urbana-Champaign are pursuing memory energy management for these data servers by investigating DMA-aware multi-processor memory energy management for multi-threaded data servers. The project has explored the characteristics of these data centers to better understand how they use--and sometimes waste--energy. Using this information, the researchers have developed prototypes that use up to 38.6 percent less energy while providing similar performance. (CCF)



Privacy in Database Publishing. *Credit: Alin Deutsch.*

► **Hiding Confidential Data While Posting Public Data on the Web:** Information owners (governmental, academic, commercial entities, or private citizens) are subjected to two conflicting requirements: they must publish portions of data on the Web for the benefit of data consumers but, for legal, business, or personal reasons, they must preserve the privacy of the confidential information residing in their databases. In many instances, the published data can be used by malicious consumers to infer the confidential data. Researchers at the University of California, San Diego developed concepts and tools which assist database owners in identifying portions of data that can be safely published without compromising the privacy of confidential information. This research introduces novel privacy guarantees that balance strictness and practicality. The research also proves an optimal attack strategy that guarantees no other attack can expose more about the confidential data. Users only need to test for privacy guarantees against this optimal attack instead of against an infinite number of attacks. (IIS)

Other Performance Indicators

The tables below show the change in the number of people benefiting from CISE funding, and trends in the award size, duration, and number of awards.

Number of People Involved in CISE Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	6,361	6,361	7,645
Other Professionals	649	649	780
Postdoctorates	293	293	355
Graduate Students	5,732	5,732	6,900
Undergraduate Students	1,533	1,533	1,850
Total Number of People	14,568	14,568	17,530

CISE Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	1,635	1,635	1,950
Funding Rate	28%	22%	22%
Statistics for Research Grants:			
Number of Research Grants	1,310	1,310	1,550
Funding Rate	24%	19%	19%
Median Annualized Award Size	$115,300	$120,000	$145,000
Average Annualized Award Size	$139,000	$150,000	$180,000
Average Award Duration, in years	2.9	3.0	3.0

COMPUTING AND COMMUNICATION FOUNDATIONS $180,010,000

The FY 2009 Budget Request for the Division of Computing and Communication Foundations (CCF) is $180.01 million, an increase of $36.56 million, or 25.5 percent, over the FY 2008 Estimate of $143.45 million.

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Computing and Communication Foundations	**$122.76**	**$143.45**	**$180.01**	**$36.56**	**25.5%**
Major Components:					
Research & Education Grants	114.68	135.45	172.01	36.56	27.0%
Science and Technology Centers					
STC for Embedded Networked Sensing	4.04	4.00	4.00	-	-
STC for Ubiquitous Secure Technology	4.04	4.00	4.00	-	-

About CCF:

CCF addresses current and emerging areas of computing and communication foundations: theory and incubation of computing and communication; processes and artifacts for computing and communication; signals, communication and interaction; and foundations of systems in use. Within and across these areas, CCF supports research and education activities that explore the foundations of computing and communication devices and their usage. Research and education projects supported promote advances in computing and communication theory, algorithms for computer and computational sciences, architecture and design of computers, foundations of computer languages and software, and investigations of revolutionary computing paradigms such as quantum and bio-inspired computing. CCF projects also integrate education with research to prepare future generations of computer science and engineering professionals.

In general, 58 percent of the CCF portfolio is available for new research grants. The remaining 42 percent is used primarily to fund continuing grants made in previous years.

Science and Technology Centers

CCF supports two Science and Technology Centers: 1) the Center for Embedded Networked Sensing (CENS) at the University of California at Los Angeles which is exploring embedded networked sensing systems, large-scale, distributed systems, composed of smart sensors and actuators embedded in the physical world; and 2) the Center for Ubiquitous Secure Technology at the University of California at Berkeley (TRUST). TRUST is addressing a parallel and accelerating trend of the past decade - the integration of secure, robust computing and communications capabilities across critical infrastructures, in areas such as telecommunications, finance, energy distribution, and transportation.

CCF Priorities for FY 2009

The longer-term context of the FY 2009 Request is focused on foundational ideas that will enhance American competitiveness.

Cyber-enabled Discovery and Innovation (CDI)

In support of the ACI, CCF will continue its emphasis on CDI with an investment of $13.0 million. By applying algorithmic insights broadly across science, engineering, and areas of societal importance, CDI will spark a new revolution in our understanding of the world and in our productivity. Without algorithmic insights and computational thinking, complex objects and processes such as protein folding, telecommunication networks, or manufacturing processes can only be approximately understood. In FY 2009, CCF will continue to emphasize larger, multidisciplinary projects that apply foundational ideas across multiple disciplines.

Science and Engineering Beyond Moore's Law (SEBML)
CCF is participating in the NSF-wide investment in SEBML at a level of $4.0 million, with several avenues of research and education showing promise. CCF will support fundamental research to identify promising new technologies that continue scaling-based performance gains, including, for example, the use of molecules or biomolecules as basic logic elements, the use of nanowires for gates or interconnections, and the exploitation of quantum phenomena to perform computations in parallel. In addition, CCF will continue to support research aimed at optimizing performance of existing technology. For example, CCF will support research into the architecture of multicore chips, especially the interconnection networks, to find the best design alternatives over a range of chip sizes. In addition, research on new kinds of design tools will be needed that balance performance, size and power. Finally, and most importantly, new algorithms and software engineering tools and techniques will be needed that can take advantage of large-scale on-chip parallelism. While developing these techniques through research, CCF also plans to educate a new generation in their application.

Core CCF Activities
The foundational ideas of computing and communication have changed the world and society over the last few decades. CCF will continue and extend its foundational inquiries into the inherent limits of computation and communication, into the architecture of hardware and software systems, and into the use of new technologies to compute and communicate. These investigations will further transform all fields of human endeavor. For example, theoretical investigations of coding and information will increase the security of our data systems and the privacy of their users. As another example, new concepts in architecture will provide new ways of building reliable systems from unreliable components.

In FY 2009, one of the foci of CCF core activities will be massive data sets. The world is drowning in data. Networks of scientific instruments, earth-monitoring satellites, and security cameras, as examples are generating massive amounts of data. Yet the innovation and competitiveness of web-indexing services show that making such data available and searchable brings great rewards. CCF will emphasize research into techniques for computing and communicating essential properties of massive data sets. Communication can also benefit from a data-centric view. For example, if a receiver makes use of only certain properties of a stream of data, the whole data stream does not have to be communicated. It is possible that a small fraction of the data stream will suffice to compute the properties of interest, in which case only that small fraction need be communicated. For many data streams, it is possible to essentially reconstruct the entire stream from a compressed sample. Data-centric computing and communication has the potential to do for dynamic data what web indexing services have done for static data. By making these data streams available and usable, rather than just throwing them away, we may dramatically increase American innovation and competitiveness.

Changes from FY 2008:
The FY 2009 request for CCF reflects an increase of $36.56 million directed toward core research and education as well as CDI and SEBML investments. Research in the CCF core will be allocated to activities like those described above and will help maintain a consistent proposal funding rate.

COMPUTER AND NETWORK SYSTEMS $206,910,000

The FY 2009 Budget Request for the Division of Computer and Network Systems (CNS) is $206.91 million, an increase of $33.0 million, or 19.0 percent, over the FY 2008 Estimate of $173.91 million.

Computer and Network Systems Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Computer and Network Systems	**$162.77**	**$173.91**	**$206.91**	**$33.00**	**19.0%**
Major Components:					
Research & Education Grants	132.21	147.91	180.91	33.00	22.3%
Computing Research Resources	30.56	26.00	26.00	-	-

About CNS:
CNS supports research and education activities that advance our understanding of the fundamental properties of computer systems and networks and their complexity, explore new ways to address the limitations of existing computer and networked systems to make better use of these technologies, and develop better paradigms, abstractions and tools for designing, analyzing and building next generation computer and networked systems that are robust, secure and trustworthy. To enable state-of-the-art computer science research and education, the division supports the development and use of computing research infrastructure. CNS also coordinates cross-divisional activities that foster the integration of research, education, and workforce development to prepare future generations of computer science and engineering professionals.

In general, 47 percent of the CNS portfolio is available for new research grants. The remaining 53 percent is used primarily to fund continuing grants made in previous years.

CNS Priorities for FY 2009
The FY 2009 Request for CNS focuses on NSF key investments in Cyber-enabled Discovery and Innovation; Science and Engineering beyond Moore's Law; and on strengthening existing programs such as computer systems research and revitalizing education in computing.

Cyber-enabled Discovery and Innovation (CDI)
In support of the ACI, CNS will participate in CDI at a level of $11.0 million, with emphasis in the following areas:
<u>Understanding Complexity</u>- Robust, secure and highly dependable networks are essential to support communication, coordination and collaboration in all sectors of society. New knowledge will lead to a better understanding of how complex computer systems and networks behave at scale, particularly when under stress, how they are designed and deployed, and how they evolve to support timely integration of technology innovation and meet the stringent timing and resource requirements of emerging social and scientific applications and services.
<u>Cyber-physical Systems</u>- Cyber-physical systems represent a class of physical and engineered systems at the core of human-scale structures, such as medical devices and systems, automobiles and intelligent highways, as well as large-scale applications, such as industrial process control, robotic manufacturing, aviation and airspace management and other areas. The operations of these systems are integrated, monitored, and controlled by a computational core, which is embedded, potentially distributed, and

requires real-time response. As such, the behavior of a cyber-physical system is a fully-integrated hybridization of computational (logical) and physical action. CNS research seeks new scientific foundations and technologies to enable the rapid and reliable integration of computer- and information-centric physical and engineered systems. The goal is to usher in a new generation of engineered systems that are highly dependable, efficiently produced, and capable of advanced performance in information, computation, communication, and control.
Software for Complex Systems- Within this area, CNS will support research on tools for analyzing, monitoring, debugging, and documenting software for complex systems, as well as other pertinent topics.

Science and Engineering Beyond Moore's Law (SEBML)
In support of the ACI, CNS will participate in SEBML at a level of $2.0 million, making research investments in innovative paradigms and design principles for distributed control of large-scale, parallel applications as well as new programming models and abstractions for massively parallel and data-intensive applications.

CNS Core Activities
Network Science and Engineering- The growing complexity of the Internet underscores the need to understand how future, large-scale networks can be engineered to have predictable behavior. It also raises a wide range of challenges in understanding the inter-play between the technical, economic and social drivers of our current networks and identifying their broad implications for network design. CNS will support fundamental research, emphasizing insights into the dynamics of complex networks, and transformational research leading to the architectures of future-generation networks and services. Further, a comprehensive, multidisciplinary agenda for network science and engineering research is being developed in FY 2009.
Computer Systems- CNS investments in computer systems research will focus on: distributed, mobile, and embedded systems; sensing and control systems; dynamically configured, multiple-component systems; and parallel systems. The FY 2009 Request will enable a focus on emerging areas, including data-intensive applications, self-managing and access-anywhere storage, data sharing for agile organizations, virtualization at scale, and cross-systems integration for configuration and management.
Cybersecurity- Research investments in cybersecurity, including those made through Cyber Trust, will continue, supporting a vision of a society in which networked computer systems are more predictable, more accountable, and less vulnerable to attack and abuse; are developed, configured, operated and evaluated by a well-trained and diverse workforce; and are used by a public educated in their secure and ethical operation.
Education and Workforce Development- The directorate will continue CISE Pathways to Revitalized Undergraduate Computing Education (CPATH), a program designed to equip future generations of the U.S. workforce with the computing competencies and skills necessary to insure the Nation's health, security and prosperity in the 21st century. CNS will lead the infusion of computational thinking into education at all levels and in all areas of science and engineering, and will continue its investments in Broadening Participation in Computing (BPC) to significantly increase the number of U.S. citizens and permanent residents receiving post secondary degrees in the computing disciplines.
Research Infrastructure- CNS will provide support for the acquisition, enhancement, and operation of experimental facilities that enable high-quality computing research and education. Support is also provided to enhance the computing research infrastructure in under-served institutions and to support the equipment needs of collaborative, distributed research projects.

Changes from FY 2008
Disciplinary and interdisciplinary research in CNS will increase by $33.0 million. This additional support will be allocated to research and education priorities such as those described above and will help maintain a consistent proposal funding rate in CNS.

INFORMATION AND INTELLIGENT SYSTEMS $173,600,000

The FY 2009 Budget Request for the Division of Information and Intelligent Systems (IIS) is $173.60 million, an increase of $34.67 million, or 25.0 percent, over the FY 2008 Estimate of $138.93 million.

Information and Intelligent Systems Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Information and Intelligent Systems	**$119.26**	**$138.93**	**$173.60**	**$34.67**	**25.0%**
Major Component:					
Research & Education Grants	119.26	138.93	173.60	34.67	25.0%

About IIS:
The Division of Information and Intelligent Systems supports research and education that: develops new knowledge about the role of people in the design and use of information technology; increases the capabilities of human beings and machines to create, discover and reason with knowledge by advancing the ability to represent, collect, store, organize, visualize and communicate about data and information; and advances knowledge about how computational systems can perform tasks autonomously, robustly, and flexibly.

In general, 54 percent of IIS funding is available for new research grants. The remaining 46 percent is used primarily to fund continuing grants made in previous years.

IIS Priorities for FY 2009
The FY 2009 Request for IIS focuses on NSF-wide investments in Cyber-enabled Discovery and Innovation and Adaptive Systems Technology and on new and emerging research areas in human computer systems.

Cyber-enabled Discovery and Innovation (CDI)
To address CDI’s thrust on gaining knowledge from data, IIS will invest $9.63 million in research targeting new data technologies that can scale as technologies continue to increase the quantities, speed, and dimensionality of data, as well as in research attempting to cope with data heterogeneity due to the varying data resolutions, scales, modalities, sources, and inherent representational complexities confronted in scientific and engineering data. These challenges also require the development of new, suitable computational platforms, especially in the emerging data-intensive computing paradigm, which represents a rethinking of how computation is done when computing must reside where the data are, rather than the reverse. To address CDI’s thrust on virtual organizations IIS will support research developing novel computing and communication infrastructure serving the needs of demanding scientific and engineering domains.

Adaptive Systems Technology (AST)
The robustness and adaptability of biological organisms have been a rich source of metaphors and models in computer and information science and engineering. IIS anticipates providing $3.49 million to support new research directions in which adaptive systems technology informs the problems and approaches taken within CISE research. Efforts to replicate the physical behaviors exhibited by living organisms can

provide ways to build systems that exhibit greater robustness than today's robots, thereby opening up new environmental niches in which we can contemplate novel pursuits in robotics research and providing a tool for "synthetic biology" by implementing and testing hypothesized mechanisms that might underlie behaviors exhibited by biological organisms. Brain-machine interfaces can provide new ways for computers and humans to interact based on better understanding of the human nervous system and how electronic technology can interface with it, paving the way for tools that behave as if they are a part of the nervous system, neural prosthetics that restore and supplement various functions lost during disease or injury, and more direct modes of interaction between man and machine. CISE research in adaptive systems technology can help with computational modeling and understanding the representations and computations that underlie biological organisms, including, importantly, understanding intelligence as a computational process.

Human-Computer Systems
Although computing is now pervasive in all aspects of human endeavor, the design of computing and communications systems is still largely *ad hoc*, developed by their designers via informal and poorly articulated intuitions about the human use of computing, whether at the level of individuals, groups, organizations, or societies. In 2009 IIS will target the development of efforts that explicitly build up our knowledge of how people interact with information technology, and how information technology design can be explicitly informed by such knowledge. IIS plans to support work that tackles such questions as: How does the human cognitive system constrain the ways we can most effectively use computing systems? How can computing systems bring together people to achieve results that are beyond the capabilities of either computers or people when acting in isolation? How does the structure and nature of our computing and information networks enable or constrain our ability to harness the combined strengths of computers and people working together? Although we have models of computability for a computer acting in isolation, can models be developed that provide insight and guide future development of systems in which humans and computers work together?

IIS Core Activities
IIS will increase its investments in the core areas of Information and Intelligent Systems, reflecting the continuing and growing importance of such topics as: accessing and understanding digital content in a broad range of heterogeneous forms; physics-based modeling for computational vision, robotics, computer graphics, and other areas that require accurate interaction with and representation or depiction of the physical world; building systems that exhibit the broad competencies and robust behaviors exhibited by humans and other biological organisms; and understanding the role of people – whether singly, in teams, or in society at large – in the context of computing technologies ranging from mobile platforms to virtual worlds to ubiquitous computing environments.

Changes from FY 2008
The FY 2009 Request for IIS includes an increase of $34.67 million that will be directed to core disciplinary and interdisciplinary research. This additional support will be allocated to research priorities as described above and will help maintain a consistent funding rate in IIS.

INFORMATION TECHNOLOGY RESEARCH $78,240,000

The FY 2009 Budget Request for the Information Technology Research (ITR) subactivity is $78.24 million, equal to the FY 2008 Estimate.

Information Technology Research Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Information Technology Research	**$121.89**	**$78.24**	**$78.24**	**-**	**-**
Major Component:					
Research & Education Grants	121.89	78.24	78.24	-	-

About ITR:

The ITR subactivity provides support for transformative explorations in computer information science and engineering research and related education activities, emphasizing the funding of multi-investigator, often multidisciplinary, projects.

In general, 70 percent of the ITR portfolio is available to make new research awards. The remaining 30 percent is used primarily to fund continuing grants made in previous years.

ITR Priorities for FY 2009

Funds from the ITR subactivity will be used to target prominent CISE-wide IT research and education priorities as described below.

Explorations

At a level of $50.0 million, CISE will support larger-scale, often multidisciplinary, research and education projects that promise fundamental new knowledge in computing, and IT systems that are more reliable and robust, have better and more predictable performance, provide useful new services, and exploit the potential of emerging technologies. Funded projects will permit full development and exploration of fundamental new concepts and ideas in the computing domain, and promise significant contributions to the ACI.

Established in 2008, the Expeditions in Computing program is a key component of the Explorations portfolio. The program provides CISE PIs with the opportunity to pursue ambitious, fundamental research agendas that promise to define the future of computing and information. In planning and implementing *Expeditions*, investigators are encouraged to come together within or across departments or institutions in the identification of compelling, transformative research agendas that promise disruptive innovations in computing and information for many years to come. Funded at levels up to $2.0 million per year, *Expeditions* represent some of the largest single investments currently made by the directorate. Together with the Science and Technology Centers CISE supports, *Expeditions* form the centerpiece of the directorate's award portfolio. With awards funded at levels that promote the formation of research teams, CISE recognizes that concurrent research advances in multiple fields or sub-fields are often necessary to stimulate deep and enduring outcomes.

ENGINEERING $759,330,000

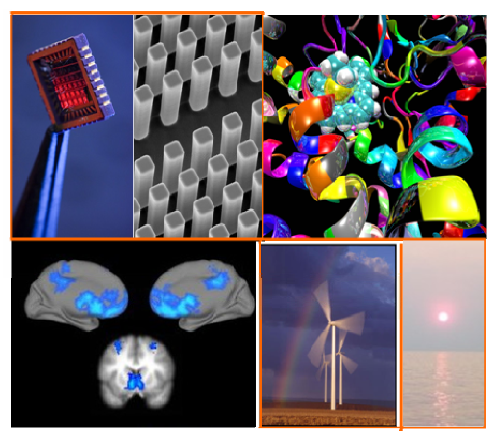
The FY 2009 Budget Request for the Directorate for Engineering (ENG) is $759.33 million, an increase of $122.46 million, or 19.2 percent, over the FY 2008 Estimate of $636.87 million.

Engineering Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Chemical, Bioengineering, Environmental and Transport Systems (CBET)	$128.27	$131.00	$173.34	$42.34	32.3%
Civil, Mechanical and Manufacturing Innovation (CMMI)	157.30	159.81	201.88	42.07	26.3%
Electrical, Communications and Cyber Systems (ECCS)	83.24	83.50	94.36	10.86	13.0%
Industrial Innovation and Partnerships (IIP)	120.78	121.67	140.90	19.23	15.8%
SBIR/STTR	*108.67*	*109.37*	*127.00*	*17.63*	*16.1%*
Engineering Education and Centers (EEC)	115.16	115.89	119.85	3.96	3.4%
Emerging Frontiers in Research and Innovation (EFRI)	25.25	25.00	29.00	4.00	16.0%
Total, ENG	$629.99	$636.87	$759.33	$122.46	19.2%

Totals may not add due to rounding.

From manufacturing nano-sized devices to bolstering the Nation's energy security, engineering research and education enable innovative solutions to society's most significant challenges. The systems approach inherent to engineering is becoming crucial for resolving increasingly complex problems and relentlessly advancing the frontiers of knowledge and innovation by integrating multiple disciplines.

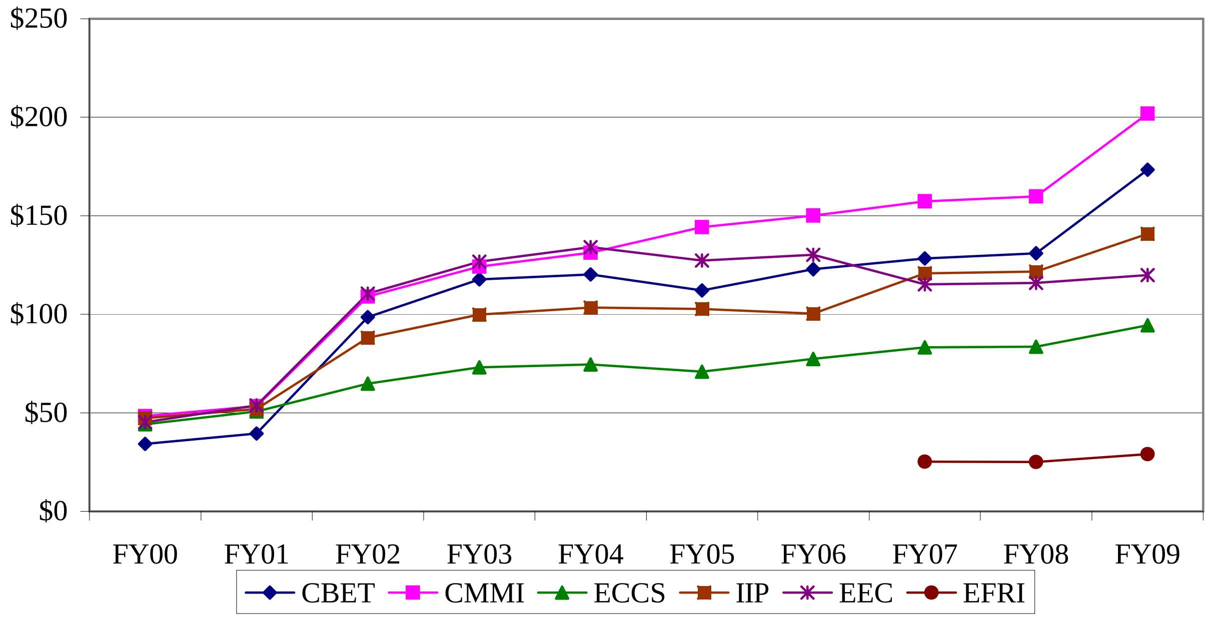


Engineering spans the frontiers: micro- and nano-scale materials, modeling of complex systems, technology and human abilities, and alternative energy.

Engineers are uniquely positioned to not only advance fundamental understanding, but also to transform discovery into the innovation essential to the nation's prosperity, national security, quality of life, and economic competitiveness.

The innovation fueled by engineering improves every component of society: advances in nanotechnology and intelligent manufacturing to create new materials and redefine how materials and structures are designed; algorithms to control and predict complexity in systems including atomistic structures, factories, the national power grid, and the global economy; better technologies for harnessing and storing renewable energy; complex models and sensors for assessing and monitoring water resources, climate change, and the environment; biocompatible materials for improving human health; and new approaches to medical treatment and monitoring.

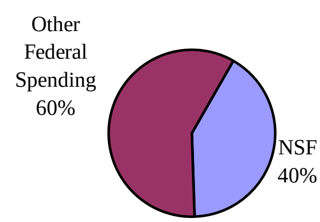
ENG Subactivity Funding
(Dollars in Millions)



RELEVANCE

The Directorate for Engineering provides 40 percent of the total federal support in university-based, fundamental engineering research. Having started the National Nanotechnology Initiative in 2000, the Directorate for Engineering continues to steer the basic and frontier engineering research that fuels U.S. technology.

Federal Support of Basic Research in Engineering at Academic Institutions



The following research themes for fiscal year 2009 define transformative research directions. These themes answer key challenges that are recognized by technology and government leaders and that are set forth in the American Competitiveness Initiative (ACI) and the America COMPETES Act.

Cognitive Engineering: Intersection of Engineering and Cognitive Sciences. Engineering and neuroscience knowledge are overlapping, particularly in cognitive engineering, which works in two directions: first, developing technologies to improve understanding of brain functions, particularly learning, as well as technologies that improve human productivity and potential; and second, using this understanding to engineer powerful systems and devices that simulate neural networks. Such systems and devices can bolster monitoring of large-scale, complex systems, and also enable dynamic optimization and advanced decision-making. Understanding the systems behind human intelligence can help in designing robotic intelligence. Smart machines that sense and adapt autonomously are the kinds of competitive innovations envisioned for both ACI and America COMPETES. This research also has the potential to provide new knowledge and technologies – as well as a systems-based understanding of the brain and nervous system – to bolster the NSF-wide investment in Adaptive Systems Technology.

Competitive Manufacturing and Service Enterprises. Increasingly a knowledge-based industry, manufacturing is experiencing a paradigm shift, redefining the properties of materials and the assembly and robustness of structures of all scales. Advances in nanomanufacturing can lead to lower-cost materials having designed-in properties. These advances are enabled by implementation of advanced sensors and control theory, and these processes can translate to effective delivery of services such as wireless access, transportation, and even medical information. Thus, advances in manufacturing processes also sharpen U.S. competitiveness in the service sector, a primary U.S. employer and a major industry in the global, knowledge-based economy. Supporting research that can increase U.S. manufacturing competitiveness directly meets one of the goals set for NSF in the America COMPTES Act. It also bolsters the ACI goals and initiatives of creating world-class capability and capacity in nanofabrication and nanomanufacturing; improving sensor and detection capabilities resulting in world-leading automation and control technologies; and transforming health care through information technology.

Complexity in Engineered and Natural Systems. The Nation's infrastructure, such as the national power grid; the environment and its changes due to a warming climate; security, such as predicting and responding to adversarial behavior; healthcare and its delivery; and the economy, which is affected by how people react to information – all these involve large numbers of interacting elements and people and suggest many of the issues of complex systems. To understand, predict, describe and design for complex behavior requires a fundamental understanding of complexity, a goal yet to be reached. Investment is crucial for research advancing knowledge of complexity, developing high-end computing capability for modeling complex systems, realizing transforming technologies based on understanding complexity, and strengthening the community's ability to work across disciplines. It also addresses the ACI goals of addressing gaps and needs in cyber-security and information assurance to protect our IT-dependent economy; and enabling scientific advancement through modeling and simulation at unprecedented scale and complexity. Furthermore, these advances will also support the specific needs – such as networking protocols and architectures that make systems more resilient – set by America COMPETES for NSF to enable research that advances communication and information technology for all citizens.

Energy, Water and the Environment. The development of new energy sources must harness and distribute energy from renewable sources and lessen the burden of power generation on the water supply, itself already affected by climate change. Frontier research in all fields of engineering can drive essential breakthroughs for developing systems that increase the efficient use of energy and thus lessen demand; for understanding, modeling and developing methods to minimize water use during energy production; for monitoring the supply and quality of water in order to better manage them; and for addressing the ACI goal of overcoming technological barriers to efficient and economic use of hydrogen and solar energy. Engineering research builds knowledge in biofuels, hydrogen production, solar cells, energy conversion and storage, power distribution, and carbon sequestration – all crucial to securing energy security and to reducing the accumulation of greenhouse gases in the atmosphere.

Systems Nanotechnology. The potential of successfully manipulating matter at the nanoscale is only beginning to be realized. The next frontier in nanotechnology is to create controllable systems built from nanoscale components. Such systems will support crucial applications, such as petascale computing; designing-in properties by manufacturing materials from the nanoscale; regenerating human tissue and organs from the nanoscale; designing systems of nano-sized sensors for use in medicine, agriculture, biological research, or national security; selectively filtering harmful particles from water; and manufacturing devices, such as solar cells, that efficiently convert and store renewable energy. Advances in nanotechnology permeate all facets of society, and thus meet many of both the ACI and America COMPETES goals, such as realizing commercial use of renewable energy; developing world-leading high-end computing capability (at the petascale) and capacity; creating world-class capability and capacity in nanofabrication and nanomanufacturing; and realizing materials breakthroughs critical to cutting-edge research (ACI); and nanoelectronics for advancing communications and information technology.

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, ENG...……….………………………………………………….....................…$636.87

Chemical, Bioengineering, Environmental and Transport Systems (CBET) +$42.34

CBET research brings engineering together with the physical sciences, with the information sciences and with the life sciences, uniquely positioning the CBET community to address complex problems. The Division will increase support in key applications of the physical sciences, such as catalysis, chemical process design, environmental engineering, advanced materials, fuel cells, fluid flow, combustion, heat transfer, and particulate processes. These investments contribute to advances that are important for energy, the environment, transportation, information technologies, health-related products, and other areas that both impact our daily lives and sustain and enhance U.S. competitiveness.

Current high-emphasis applications of the life sciences include postgenomic engineering, tissue engineering, biophotonics, nano-biosystems, and biotechnology. Increased support will lead to improved biosensors, biomaterials, controlled drug release, bioimaging, medical devices and instrumentation, artificial organs, therapeutic agent bioprocessing, bioremediation, water and waste treatment, and food engineering.

Civil, Mechanical and Manufacturing Innovation (CMMI) +$42.07

Provides increased support in the areas related to analyzing, modeling, designing, building, and securing the nation's critical infrastructure, and for strengthening its manufacturing and service enterprises. CMMI will continue to increase investments in engineering education to foster a world-class engineering workforce. Support will also be increased for projects utilizing the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) and for hazard-related research.

Electrical, Communications and Cyber Systems (ECCS) +$10.86

Provides increased support for innovative research in nano and micro systems, and communication systems and cyber systems that integrate physical devices and components with computational intelligence and networks. This research will aid in the design, development, and implementation of new complex and hybrid systems with engineering solutions for a variety of domain-specific applications to benefit society. Additional funds will also support core research in the emerging areas of diagnostic and implantable devices; flexible electronics; neuromorphic engineering; quantum electronics; energy scavenging and alternative energy technologies; and interdependencies of critical infrastructure in power and communications.

Industrial Innovation and Partnerships (IIP) +$19.23

IIP is home for the two legislatively mandated small business research programs, the Small Business Innovation Research (SBIR) program (+$15.77 million) and the Small Business

Technology Transfer (STTR) program (+$1.86 million). In addition, IIP leverages industrial support through two research programs, the Industry/University Cooperative Research Centers (I/UCRC) program (+$870,000) and the Grant Opportunities for Academic Liaison with Industry (GOALI) program (+$730,000).

Engineering Education and Centers (EEC) +$3.96

In FY 2009, EEC will provide support for Engineering Research Centers, Nanoscale Science and Engineering Centers, engineering education research, and engineering workforce development. Research will be supported to improve the development, management, and productivity of quality engineering education at both the undergraduate and graduate levels. Topics of particular interest include: the aims and objectives of engineering education, the content and organization of the curriculum, how students learn problem solving, how to encourage creativity and design, developing new methods for assessment and evaluation of how students learn engineering, understanding the business aspect of engineering education, and conducting research that helps us understand how to attract a more talented and diverse student body to all levels of engineering study.

Emerging Frontiers in Research and Innovation (EFRI) +$4.00

EFRI support increases by $4.0 million and will foster transformative opportunities that are interdisciplinary and high risk with high potential payoff leading to: new research areas for NSF, ENG, and other agencies; new industries or capabilities that result in a leadership position for the country; and/or significant progress on a recognized national need or grand challenge. EFRI was established in FY 2007 to bring together researchers from different disciplines who work at the frontiers where new knowledge is generated. Now that global competition is increasing, the technical underpinnings of the past may not be adequate to ensure our continued success. EFRI will provide critical, strategic support of fundamental discovery, particularly in areas leading to breakthrough technologies.

Subtotal, Changes +$122.46

FY 2009 Request, ENG ……………………………………………………………………........$759.33

Summary of Major Changes in Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, ENG…………………………………………………………………….....$636.87

<u>Discovery</u> +$116.37

ENG has a vital role to play in advancing focus areas and the Foundation-wide activities for FY 2009. Engineering-supported research will be especially relevant in the following areas:

Cyber-enabled Discovery and Innovation (+$8.81 million).

ENG increases will support simulation-based engineering and science, a crucial and far-reaching capability enabled by cyberinfrastructure. As cyber-enabled discovery advances, so too must the use of it, such as multiscale modeling, sensor systems, simulation, and integration of large data sets. These advances can allow predictive decision-making. The next generation of models will rapidly synthesize design alternatives for large and complex systems, and will simultaneously capture changes through space and time across many components of multiscale systems and processes.

Science and Engineering Beyond Moore's Law (+$4.0 million).

Engineering contributions are fundamental to advances in this area. For example, research in nanomanufacturing, photonics, micro- and nanoelectronics, and molecular electronics, will result in the new materials and devices – such as silicon microelectronics that exploit properties at the quantum level – required to realize computing capacity beyond the limits suggested by Moore's Law.

Adaptive Systems Technology (+$3.49 million).

ENG will support this NSF-wide investment, particularly in the area of neural engineering, an emerging field that bridges molecular, cellular, systems, cognitive, and behavioral neuroscience with engineering, physics, chemistry, mathematics, and computer science. This field promises to develop engineering techniques and systems that will enable new understanding of the brain, nervous and sensory systems, and other crucial processes in the body, and the use of this understanding in engineered systems.

Dynamics of Water Processes in the Environment (+$530,000).

The fulcrum point of this research is forecasting: supporting research for monitoring changes in the water supply and its quality, anticipating droughts or flooding, and understanding how human activity and environmental changes affect dynamics in water supplies. ENG will support research to develop monitoring methods, particularly advanced sensor systems and networks, as well as modeling for a variety of applications, including monitoring of natural and human-built water systems. ENG will support this activity to bolster research on society's critical need to strategically manage a finite resource for which demand is growing.

Disciplinary and Interdisciplinary Research (+$72.85 million).

An increase of $72.85 million will bring support for core research areas to a total of $370.88 million. ENG will continue to build on its strong system of merit review and investigator-initiated proposals, which advance the frontiers of knowledge and innovation by working across traditional boundaries and encouraging multidisciplinary, cutting-edge, and high-impact research including the Climate Change Technology Program. ENG's core represents a broad and synergistic convergence of fields, disciplines, and frontier opportunities. This core supports both newly emerging fields and long-standing challenges that are poised for major advancement. The Office of Emerging Frontiers in Research and Innovation will continue to identify, prioritize, and fund emerging areas in engineering research, innovation, and education.

Faculty Early Career Development Program (CAREER) (+$7.45 million).

Funding increases by $7.45 million, to a total of $45.85 million, to provide 18 additional awards.

Nanoscale Science and Engineering Centers (NSEC) (+$720,000).

Funding increases by $720,000, to a total of $24.75 million, to provide for planned expansion of one center.

Engineering Research Centers (ERC) (+$690,000).

Funding increases by $690,000, to a total of $53.55 million, to provide for the planned growth of the 2008 class of Generation-3 ERCs.

Industry/University Cooperative Research Centers (+$870,000).

Funding increases by $870,000 to a total of $7.57 million. Engineering support provided to each center will increase by approximately $10,000 per center. The NSF investment in this program leverages investment of approximately $65.0 million annually from industry, university, state, and other federal partners.

Science and Technology Center (-$670,000).

Funding for the Nanobiotechnology Science and Technology Center decreases by $670,000, to a total of $2.66 million, as the Class of 2000 centers receive final-year phase-down funding.

Small Business Innovation Research/Small Business Technology Transfer (+$17.63 million).

Funding increases by $17.63 million, to a total of $127.0 million to meet the mandated agency spending target of 2.80 percent of the agency's extramural research budget.

<u>Learning</u> +$2.54

Integrative Graduate Education & Research Traineeship program (IGERT) (+$290,000).

Funding for the IGERT program increases by $290,000, to a total of $7.59 million, and will support additional students through this program.

Research Experience for Undergraduates (REU) (+$1.65 million).

Including REU Sites and REU Supplements, this program increases by $1.65 million, to a total of $14.45 million, providing support to approximately 80 additional students.

Research Experiences for Teachers (RET) (+$600,000).

Including support for the RET Sites and Supplements, this program increases by $600,000, to a total of $5.20 million, providing research experiences for approximately 60 additional teachers.

<u>Research Infrastructure</u> +$0.85

Network for Earthquake Engineering Simulation (+$850,000).

Funding for operations and maintenance costs increases by $850,000 to a total of $23.02 million, to provide for inflationary increases at the 15 equipment sites that make up this national network.

<u>Stewardship</u> +$2.70

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$122.46

FY 2009 Request, ENG………...…………………………………………………...…..….$759.33

NSF-WIDE INVESTMENTS

In FY 2009, ENG will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

Engineering NSF-wide Investments

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Adaptive Systems Technology	-	-	$3.49	$3.49	N/A
Climate Change Science Program	1.00	1.00	1.00	-	-
Cyber-Enabled Discovery and Innovation	-	8.00	16.81	8.81	110.1%
Cyberinfrastructure	54.00	56.00	60.00	4.00	7.1%
Dynamics of Water Processes in the Environment	-	-	0.53	0.53	N/A
Human and Social Dynamics	2.00	1.50	-	-1.50	-100.0%
National Nanotechnology Initiative	137.02	137.02	140.02	3.00	2.2%
Networking and Information Technology R&D	11.20	19.20	28.01	8.81	45.9%
Science & Engineering Beyond Moore's Law	-	-	4.00	4.00	N/A

Adaptive Systems Technology: ENG will support this NSF-wide investment, particularly in the area of neural engineering, an emerging field that bridges molecular, cellular, systems, cognitive, and behavioral neuroscience with engineering, physics, chemistry, mathematics, and computer science. This field promises to develop engineering techniques and systems that will enable new understandings about the brain, nervous and sensory systems, and other crucial processes in the body. ENG provides a foundation for this initiative through the research supported by its Cognitive Engineering theme.

Cyberinfrastructure (CI): ENG currently funds the operation and research program of NEES, the George E. Brown Jr. Network for Earthquake Engineering Simulation. NEES is NSF's first distributed-network cyberinfrastructure research facility. In FY 2009, support increases by $4.0 million to a total of $60.0 million and will fund ENG projects at the device, node, network, and system levels that will enable enhanced capabilities for the next generation of cyberinfrastructure. Funding will support projects that use cyberinfrastructure to enable frontier research in ENG domain areas.

Dynamics of Water Processes in the Environment: The fulcrum point of this research is forecasting: supporting research for monitoring changes in the water supply and its quality, anticipating droughts or flooding, and understanding how human activity and environmental changes affect dynamics in water supplies. ENG will support research to develop monitoring methods, particularly advanced sensor systems and networks, as well as modeling for a variety of applications, including monitoring of natural and human-built water systems. ENG will support this initiative to bolster research on society's critical need to strategically manage and secure a finite resource for which demand is growing.

National Nanotechnology Initiative (NNI): NSF leads the U.S. nanotechnology research effort, and ENG is the focal point within NSF for this critical national research endeavor. The goal is to support fundamental research and catalyze synergistic science and engineering research and education in emerging areas of nanoscale science and technology as well as research directed at the environmental, health, and safety (EHS) impacts of nanotechnology. ENG supported research can push nanotechnology to the next step, from the present development of passive nanostructures to the next-generation of active nanostructures that would function as devices and systems. Applications include creating new materials that are built, and could even self-assemble, from the nanoscale; realizing petascale computing; regenerating human tissue and organs from the nanoscale; designing systems of nano-sized sensors for monitoring a human's health, a water supply's volume and quality, or an infrastructure; and manufacturing devices, such as solar cells, that efficiently convert and store renewable energy.

Networking and Information Technology Research and Development (NITRD): ENG supports an array of fundamental computer and network research, including the Control, Networks and Computational Intelligence (CNCI) program, which covers creative research and education underlying the analysis and design of intelligent engineering networks for control, communications, computation, and energy.

Science and Engineering Beyond Moore's Law: With silicon-based technologies and materials, computer processing power does in fact have a limit. This initiative supports research aimed at using new materials, methods, algorithms and knowledge to meet increasingly higher needs for computer processing power, information storage, reduced energy usage, and other computing demands. It is time now to exploit quantum states and interactions, new connection architectures, and new algorithms.

QUALITY

ENG maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. In FY 2007, the last year for which complete data exist, 96 percent of research funds were allocated to projects that underwent external merit review.

To ensure the highest quality in processing and recommending proposals for awards, ENG convenes Committees of Visitors, composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review, and provide a retrospective assessment of the quality of results of NSF's investments. The Division of Electrical, Communications and Cyber Systems (ECCS) will be reviewed in FY 2008 and the Chemical, Bioengineering, Environmental and Transport Systems (CBET) and Civil, Mechanical and Manufacturing Innovation (CMMI) divisions will be reviewed in FY 2009.

ENG also receives advice from the Advisory Committee for Engineering (AC/ENG) on such issues as: the mission, programs, and goals that can best serve the engineering community; how ENG can promote quality graduate and undergraduate education in the engineering sciences; and priority investment areas in engineering research. The AC/ENG meets twice each year. Its members represent a cross section of engineering, with representatives from many different sub-disciplines within the field. Members also come from a variety of institutions, have broad geographic representation, and represent a balance of underrepresented groups.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Engineering Funding
By Strategic Outcome Goal
(Dollars in Millions)

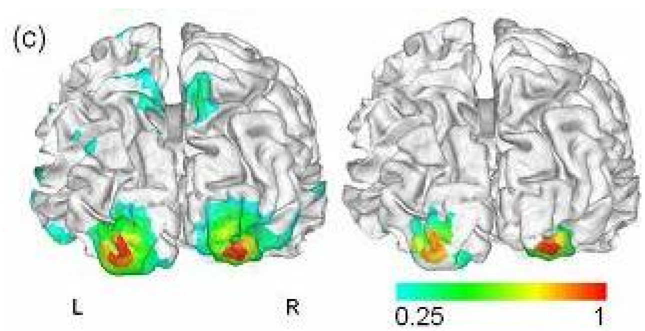
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Discovery	$543.18	$544.72	$661.09	$116.37	21.4%
Learning	47.96	52.08	54.62	2.54	4.9%
Research Infrastructure	30.40	31.57	32.42	0.85	2.7%
Stewardship	8.46	8.50	11.20	2.70	31.8%
Total, ENG	$629.99	$636.87	$759.33	$122.46	19.2%

Totals may not add due to rounding.

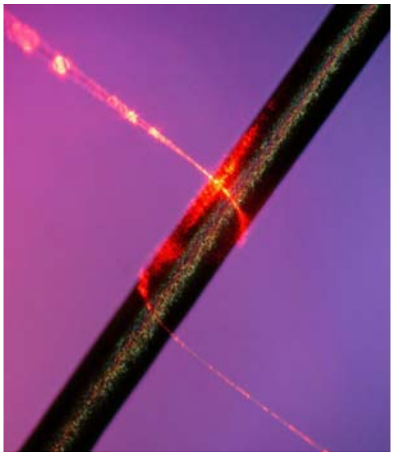
ENG will continue its commitment to education, training, and increasing diversity within all of its Divisions. The FY 2009 budget will maintain award size and continue to focus on multidisciplinary research activities, interagency partnerships, and international activities with special attention given to broadening participation at all levels.

Recent Research Highlights

► **Mapping the Brain in Time and Space:** Electroencephalography, or EEG, is a method for mapping brain activity in close to real-time. However, it cannot pinpoint the location of that activity accurately. Functional magnetic resonance, or fMRI, can help to pinpoint the spatial origins of activity, but not quickly enough. Treating neurological diseases requires mapping brain activity at a high resolution in both time and space. Researchers from the University of Minnesota-Twin Cities have conducted integrated, high-resolution functional mapping by taking simultaneous measurements with both EEG and fMRI and integrating the data. They also developed an algorithm to reconcile inconsistencies between the two methods. This combined approach offers a new window into brain functions and has major biomedical applications. (CBET)

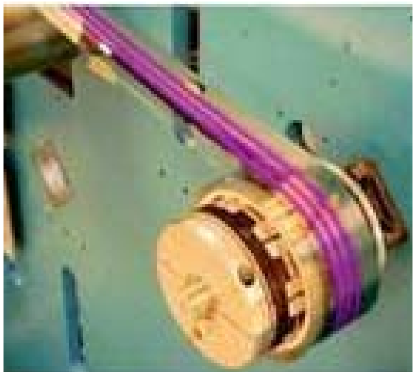


Comparison between cortical imaging from EEG alone (left) and the multimodal imaging integrating EEG and fMRI (right). *Credit: Bin He, University of Minnesota-Twin Cities.*



► **Light at the Nanoscale: Vast Potential:** Researchers at Harvard have developed a technique for fabricating nanowires that could propel the miniaturization of microphotonic devices and transform telecommunications. They developed a novel method for successfully thinning a silica fiber to a diameter as small as 100 nanometers. At this size, light moves along the nanowire like a train along rails, rather than moving contained within the wire as it does in fiber optic cables. This difference opens a vast array of flexibility and possibility in manipulating light at the nanoscale – including the development of high-resolution sensors or of optical transistors, a gateway to optical computer chips. The team is also developing fundamental knowledge of the nonlinear behavior of light at the nanoscale. (ECCS)

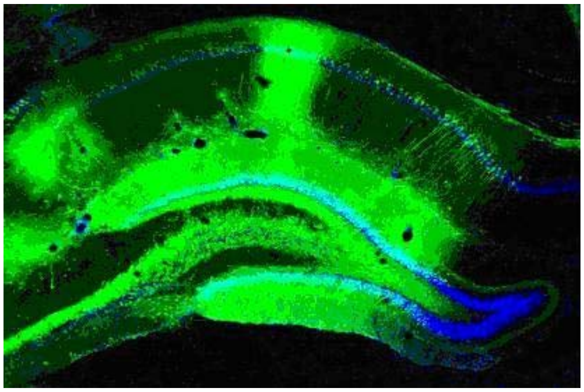
Light moves along a nanowire, pictured here wrapped around a human hair. *Credit: Eric Mazur, Harvard University.*



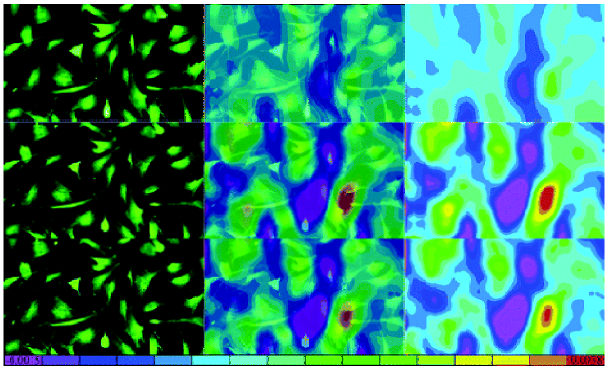
► **High-Efficiency Plastic Solar Cell:** The widespread use of solar cells is hampered not only by how efficiently the cells convert sunlight into electricity, but also by the need to lower production costs for commercial use. With Phase II funding from the Small Business Innovation Research program, Konarka Technologies Inc. has developed a lightweight, flexible, low-cost, and more efficient solar cell. The cells are actually plastic reels coated with layers of dye-sensitized titania nanoparticles in a high-volume, continuous process. The dyes enable the cells to capture relatively larger portions of the visible spectrum and to absorb more of its energy. (IIP)

Konarka's roll-to-roll, high volume manufacturing process produces thin, flexible solar cells. *Credit: Konarka Technologies Inc.*

► **Engineering Viruses to Transform Gene Therapy:** Gene therapy is a process of inserting specified genes into tissue. This enhancement of genetic information could offer a means for permanently curing many crippling diseases caused by genetic defects. One challenge of gene therapy is the safe and effective delivery of the genes. Researchers at the University of California-Berkeley are developing a process to engineer viruses, which deliver genes as part of their life cycle. The engineered viruses could deliver specific genes into designated portions of the genome of targeted cells, and do so with less risk to the immune system. The process uses directed evolution, an algorithm that mimics evolution by generating a large library of viruses and selecting out the appropriate mutation. Currently, the team has engineered a virus that targets one cell type common in the brain. (CBET)



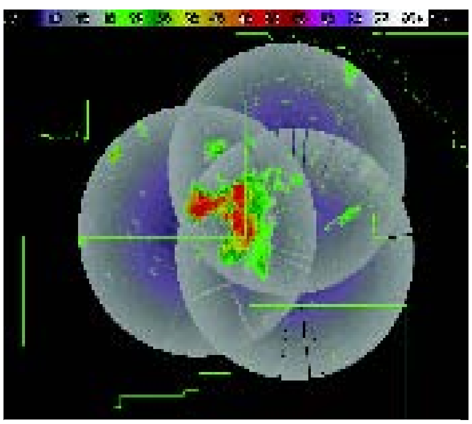
Pictured is the hippocampus of an adult rat brain (the hippocampus may be the site of Alzheimer's formation in humans). The blue cells are the original tissue. The green areas are where the engineered virus, which carried a gene encoding the green fluorescent protein (GFP), have successfully entered the hippocampus and delivered the GFP gene. *Credit: David Schaffer, University of California at Berkeley.*



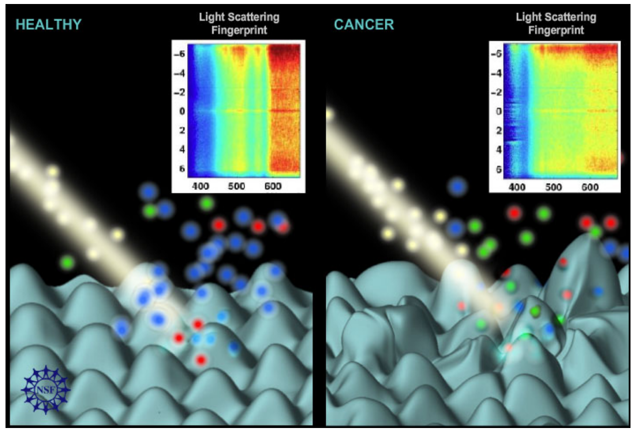
The way gold nanorods respond to light makes it possible to track how a group of cells (pictured at left) placed in a collagen film (middle and right) push (violet areas) and stretch (red areas) their surroundings as they adjust to a new environment. *Credit: Sarah Baxter, University of South Carolina.*

► **Nanorods Outline Cell-Induced Changes in Collagen:** Research is showing that the way cells respond to mechanical changes in their environments is critical to how those cells, and the tissues they comprise, function. A team of University of South Carolina (USC), Columbia, researchers is studying this interaction at the cellular level and in three dimensions, a critical ability. Metallic nanoparticles are useful tools for studying biological systems because of their size and because, with darkfield microscopy, they produce a pattern of bright scattered light in the visible spectrum. The USC team inserted gold nanorods into a cell-populated collagen film. Digital image analysis allowed tracking of the movement and deformation of the light pattern, and thus of deformation between cells, as the cells tested their environment. Watching the dynamics of the mechanical environment at the micro-scale can be used to predict a tissue's bulk properties that evolve from changes in its microstructure. This understanding can aid in many applications, including tissue regeneration. (CMMI)

► **Network Collects Data for Predicting a Tornado**: Atop a communications tower in tornado alley in Oklahoma is a large white dome ready to collect information from the lower atmosphere, specifically about rainfall and wind. Microwave pulses bounce back with more energy from clouds filled with more water. The sensor is part of a new network that will collect data, transmit it via wireless communication, and help to determine rainfall and track the hot spots in a storm. The Center for Collaborative Adaptive Sensing of the Atmosphere, an Engineering Research Center, aims to detect, predict and warn of tornados and other weather hazards. Now online, its first testbed of a network of distributed radar sensors covers 7,000 square kilometers of tornado alley. The network collects real-time data near the ground, where existing long-term Doppler techniques don't measure. As part of its work with the Experimental Warning Project run by the National Oceanic and Atmospheric Administration, the network last spring detected the presence of a tornado not seen by existing techniques. The network is designed to adapt itself to collect data in a form needed by specific end-users, such as the local meteorologist or emergency responders. (EEC)



This radar image was generated from reflectivity data collected by the CASA testbed radar network in southwestern Oklahoma. The data revealed morphological details of this Aug. 15, 2006, storm not visible with current methods. *Credit: David McLaughlin, CASA Engineering Research Center.*



At the nanoscale, light scatters differently from cancerous tissue than it does from normal tissue. *Credit: Nicolle Rager Fuller, National Science Foundation.*

► **Early, Non-invasive Detection of Pancreatic Cancer:** Using novel light-scattering techniques, researchers have found the first evidence that early stage pancreatic cancer causes subtle changes in part of the small intestine. The easily monitored marker may ultimately enable a non-invasive procedure that can detect the cancer early, much earlier than current detection procedures allow. Pancreatic cancer has no obvious symptoms, a primary reason it killed more than 33,000 people in the United States last year. Also, the pancreas can become dangerously inflamed if examined directly, so routine inspections for at-risk patients are usually not an option. The new detection techniques, produce an optical fingerprint gathered from altered tissue in the small intestine, then enhance the data for a clearer diagnosis. Researchers scanned tissue samples from 19 people already diagnosed with pancreatic cancer and 32 without the disease. They properly distinguished patients with cancer at an accuracy approaching 100 percent. The clearest results came from patients in the earliest stages of the disease. Moreover, the new technique works at the nanoscale, allowing it to differentiate cancerous or pre-cancerous tissue from normal tissue, even if the specimens look identical under a normal biopsy. (CBET)

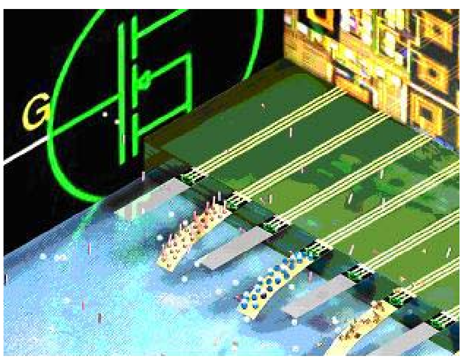


Illustration of the technique's potential: a chip hosting multiple sensing pairs that can, in real-time, detect the presence of several different molecules in parallel. *Credit: Vinayak P. Dravid and Soo-Hyun Tark, Northwestern University.*

► **Using Transistors to Sense Biomolecules:** A unique sensor system could potentially detect the presence of heart disease from a person's drop of blood or detect the presence of chemicals used for explosives. The technique uses microcantilevers, long exploited for sensing. Biomolecules (such as specific types of DNA or specific proteins) placed on the microcantilever uniquely bind with target molecules in a specific environment, such as a liquid or gas. Their binding causes surface stress that bends the microcantilever. Traditionally, optics has been used to measure microcantilever bending. Instead, researchers have embedded transistors (specifically, metal-oxide-semiconductor-field-effect-transistors), into the microcantilever. They found that deflections as small as 5 nanometers create measurable changes in drain current of the transistor. This alternative measuring technique affords more flexibility, such as the ability to perform high-resolution sensing in liquids or environments in which light scatters. They could also equip a chip with several cantilever-transistor pairs designed to sense different molecules, allowing sensing of the relative amounts of given molecules in an environment. They have a patent for the technique and are investigating applying it to the sensing of explosives. (ECCS)

Other Performance Indicators

The tables below show the change in the number of people benefiting from ENG funding, and trends in the award size, award duration, number of awards, and funding rates.

Number of People Involved in ENG Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	6,766	6,868	7,760
Other Professionals	1,385	1,406	1,589
Postdoctorates	386	392	443
Graduate Students	6,110	6,202	7,008
Undergraduate Students	3,010	3,055	3,452
Total Number of People	17,657	17,923	20,252

ENG Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	1,958	1,978	2,235
Funding Rate	20%	20%	25%
Statistics for Research Grants:			
Number of Research Grants	1,114	1,136	1,590
Funding Rate	16%	16%	20%
Median Annualized Award Size	$99,768	$99,800	$101,500
Average Annualized Award Size	$115,860	$116,000	$118,000
Average Award Duration, in years	3.0	3.0	3.0

CHEMICAL, BIOENGINEERING, ENVIRONMENTAL AND TRANSPORT SYSTEMS $173,340,000

The FY 2009 Budget Request for the Chemical, Bioengineering, Environmental and Transport Systems Division (CBET) is $173.34 million, an increase of $42.34 million, or 32.3 percent, above the FY 2008 Estimate of $131.0 million.

Chemical, Bioengineering, Environmental and Transport Systems Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Chemical, Bioengineering, Environmental, and Transport Systems	**$128.27**	**$131.00**	**$173.34**	**42.34**	**32.3%**
Major Components:					
Research and Education Grants	115.67	118.17	160.23	42.06	35.6%
Science and Technology Center (STC)	4.05	4.00	4.00	-	-
National Nanoscale Infrastructure Network (NNIN)	3.20	3.20	3.20	-	-
Nanoscale Science and Engineering Centers (NSEC)	5.35	5.63	5.91	0.28	5.0%

About CBET:

The Chemical, Bioengineering, Environmental and Transport Division supports research to enhance and protect U.S. national health, energy, environment, security, and wealth. Through CBET, the physical, life and social sciences are merged in engineering research and education, resulting in advances in the rapidly evolving fields of bioengineering and environmental engineering, and in areas that involve the transformation and/or transport of matter and energy by chemical, thermal, or mechanical means. CBET investments contribute significantly to the knowledge base and to the development of the workforce for major components of the U.S. economy, including chemicals, pharmaceuticals, medical devices, forest products, metals, petroleum, food, textiles, utilities, and microelectronics. CBET supports research in biotechnology and the chemical, environmental, biomedical, mechanical, civil, and aerospace engineering disciplines.

To achieve synergy across disciplinary boundaries, CBET is organized in four program clusters: Chemical, Biochemical, and Biotechnology Systems; Transport and Thermal Fluids Phenomena; Biomedical Engineering and Engineering Healthcare; and Environmental Engineering and Sustainability.

In general, 63 percent of the CBET portfolio is available for new research grants. The remaining 37 percent funds continuing grants made in previous years.

CBET Priorities for FY 2009:

The Division will continue to support research in key applications of the physical sciences, such as catalysis, chemical process design, environmental engineering, advanced materials, fuel cells, fluid flow, combustion, heat transfer, and particulate processes. These investments contribute to advances that are important for energy, the environment, transportation, information technologies, health-related products, and other areas that both impact our daily lives and sustain and enhance U.S. competitiveness.

Current high-emphasis areas include multi-disciplinary research funded across programs within and external to the division. This cross-disciplinary research leads to improved biosensors, biomaterials, controlled drug release, improved medical devices and instrumentation, artificial organs, therapeutic agent bioprocessing, bioremediation, water and waste treatment, and food engineering. While sustaining the vitality of these core research areas, CBET actively supports the following theme areas:

Energy, Environment, and Sustainability: CBET will continue to support research on environmentally benign processes. Energy conversion areas include green gasoline production from biomass, cleaner combustion processes, fabrication of new materials for solar cells, novel electrode materials for fuel cells, microbial fuel cells, liquid biofuels, and biohydrogen. The management of greenhouse gases with their links to climate change will be supported. CBET leads the Water and Environmental Research Systems (WATERS) Network project (NSF support of $6.20 million for FY 2009), which has, as its objective, the transformation, at a national scale, of research on water resource engineering. WATERS is aimed at observing, monitoring, and predicting the nation's water supply by integrating complex natural environments with engineered systems. Resilient, sustainable infrastructure is a new area of support for several programs within the division.

Nanoscale Science and Engineering: CBET will continue its leadership role in supporting research for designing, synthesizing, and analyzing nanoscale systems. Current emphasis is on active nanoscale systems leading to improved devices and sustainable manufacturing techniques. CBET also plays a key role in funding exploratory research on biosystems at the nanoscale. For example, chips and sensors, combined with microfluidics, are integrated intimately with nanobiotechnology. Many of these systems are for medical, environmental, and other sensing applications.

Cyber-enabled Discovery and Innovation (CDI): CDI efforts are pervasive throughout CBET's programs. Projects involving CDI are funded throughout CBET, and draw increasingly on High Performance Computing (HPC) capabilities that will be enhanced by NSF-level CDI investments. Multi-scale modeling is growing rapidly in the academic communities funded by CBET. CBET hosts the interagency solicitation on multi-scale modeling in Biomedical, Biological, and Behavioral systems. CBET is also part of an interagency working group on multi-scale chemical sciences and process informatics kinetics, and encourages strong interaction between modeling and experimental efforts.

Complex Engineered and Natural Systems: CBET invests heavily in complex natural systems through the environmental programs, including the plan for the WATERS Network, and through projects awarded in the Biomedical Engineering and Engineering Healthcare cluster. Examples of these types of awards include the development of artificial retinal implants for sight restoration and neurotechnology-based computer interfaces to allow people with brain injuries to have use of their limbs.

CBET continues to participate in major NSF-wide investments and supports large scale facilities through Science and Technology Centers, Nanoscale Science and Engineering Centers and the National Nanotechnology Infrastructure Network.

Changes from FY 2008:

- Support increases by $2.98 million for the CDI NSF-wide investment.
- Support of $1.40 million for the SEBML NSF-wide investment.
- $1.0 million in support of the AST NSF-wide investment.
- Support of $290,000 for the WATER NSF-wide investment.
- Support increases by $280,000 for Nanoscale Science & Engineering Centers.
- An increase of $36.39 million to support leading edge, frontier research in core programs and in support of the Engineering research themes.

CIVIL, MECHANICAL AND MANUFACTURING INNOVATION $201,880,000

The FY 2009 Budget Request for the Civil, Mechanical and Manufacturing Innovation Division (CMMI) is $201.88 million, an increase of $42.07 million, or 26.3 percent, above the FY 2008 Estimate of $159.81 million.

Civil, Mechanical and Manufacturing Innovation Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Civil, Mechanical and Manufacturing Innovation	**$157.30**	**$159.81**	**$201.88**	**$42.07**	**26.3%**
Major Components:					
Research and Education Grants	129.95	130.85	171.80	40.95	31.3%
Network for Earthquake Enginnering and Simulation (NEES)	20.74	22.17	23.02	0.85	3.8%
National Nanoscale Infrastructure Network (NNIN)	1.65	1.65	1.65	-	-
Nanoscale Science and Engineering Centers (NSEC)	4.96	5.14	5.41	0.27	5.3%

About CMMI:

The Civil, Mechanical and Manufacturing Innovation (CMMI) Division supports fundamental research to advance the frontiers of knowledge in order to enable a globally competitive and sustainable future for the nation. CMMI supports research to advance the domain knowledge in areas related to analyzing, modeling, designing, building, and securing the nation's critical infrastructure, and to strengthening its manufacturing and service enterprises.

CMMI programs are organized into four areas: resilient and sustainable infrastructure, manufacturing and service enterprises, mechanics and engineered materials, and engineering decision sciences. These areas will provide funds for the creation of necessary knowledge to design and secure the nation's infrastructure, and to grow our nation's wealth-producing enterprises.

A major portion of CMMI's portfolio supports the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) and hazard-related research. NEES is a system of 15 experimental facilities located at universities across the United States that work together via cyberinfrastructure. This research facility addresses important challenges in earthquake and tsunami engineering research that previously could not be addressed, such as testing structures at near to full scale. Investments in fundamental earthquake engineering and other hazard-related research enables NSF's Engineering Directorate to quickly send research teams to gather ephemeral data immediately following natural as well as man-made disasters. The fundamental knowledge gained from these investments is being used to design predictive systems for the nation's infrastructure to mitigate damage, down time, and loss of life from a wide range of hazards.

CMMI's design, manufacture, and service portfolio is the largest among the federal agencies that support fundamental research and discovery driven by innovative research ideas from the community rather than by pre-defined specifications. This has led to early investments in solid-modeling systems, optimization and network methods, and processes that provide solid representations directly from digital data and enable engineered processes for growing tissue.

In general, 67 percent of the CMMI portfolio is available for new research grants. The remaining 33 percent funds continuing projects made in previous years and operation of facilities and centers.

CMMI priorities for FY 2009:

CMMI's priorities for FY 2009 align with ENG's priorities in:

- *Cognitive Engineering* by supporting research in the areas of nano- and bio-mechanics as well as biosensors and bioactuators.
- *Competitive Manufacturing and Service Enterprises* by supporting research in the enabling processes, systems and enterprises to advance nanomanufacturing and the technology for healthcare delivery.
- *Complexity in Engineered and Natural Systems* by supporting research that leads to fundamental knowledge of complex systems and their modeling and research that leads to technologies for the protection, maintenance, or modification of the nation's critical civil and cyber infrastructure.
- *Energy, Water and the Environment* through support for research in understanding the effects of material processing on the environment and the usage of water and energy.
- *Systems Nanotechonology* by supporting research in areas that support design, analysis, and manufacture of systems based on advances in nanotechnology.

A major priority for CMMI is support for NEES research and operations, as well as the grand challenges NEES research addresses. Research will continue to involve experimental and theoretical simulations at the NEES facilities as well as expand educational outreach. CMMI is engaged with its research community to focus its investment priorities. This includes several workshops, cosponsored with DOD agencies, on fundamental research needs in the area of jointed structures; and workshops for the Mechanical, Civil, and Environmental Engineering communities to define their future research directions.

CMMI supports nanoscale science and engineering, with programs in the Mechanics and Engineered Materials cluster, including Nanomanufacturing and Nano/Bio-Mechanics. These programs have a critical role in converting discoveries into innovations, and are a key component of the Directorate's *Nanotechnology* theme and the grand challenges for the National Nanotechnology Initiative. A range of manufacturing discoveries and innovations are needed to design the systems and processes to deliver products, devices and components that take advantage of the unique properties of the nanoscale. Simultaneously, an entirely new manufacturing workforce needs to be educated and trained in nanotechnology to bring to fruition the many exciting opportunities that nanotechnology has opened up. CMMI's Nanomanufacturing program will continue to support research on improving human physical and mental abilities through the integration of nanotechnology, biotechnology, information technology, and cognitive science, as well as a new generation of tools and processes to achieve this goal.

Changes from FY 2008:

- Support increases by $3.84 million for the CDI NSF-wide investment.
- Support of $1.0 million for the SEBML NSF-wide investment.
- $1.49 million in support of the AST NSF-wide investment.
- Support of $120,000 for the WATER NSF-wide investment.
- An increase of $34.50 million to support leading edge, frontier research in core programs and in support of the Engineering research themes.
- An increase of $850,000 to a total of $23.02 million will continue to accommodate the operations phase for the Network for Earthquake Engineering Simulation.
- Support increases by $270,000 for Nanoscale Science & Engineering Centers.

ELECTRICAL, COMMUNICATIONS AND CYBER SYSTEMS $94,360,000

The FY 2009 Budget Request for the Electrical, Communications and Cyber Systems (ECCS) Division is $94.36 million, an increase of $10.86 million, or 13.0 percent, over the FY 2008 Estimate of $83.50 million.

Electrical, Communications and Cyber Systems Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Electrical, Communications and Cyber Systems	**$83.24**	**$83.50**	**$94.36**	**$10.86**	**13.0%**
Major Components:					
Research and Education Grants	71.23	72.37	83.71	11.34	15.7%
Nanoscale Science and Engineering Centers (NSEC)	3.13	3.25	3.44	0.19	5.8%
National Nanoscale Infrastructure Network (NNIN)	4.81	4.55	4.55	-	-
Science and Technology Center (STC)	4.07	3.33	2.66	-0.67	-20.1%

About ECCS:

ECCS will address fundamental research issues underlying device and component technologies, power and energy, controls, computation, networking, communications and cyber technologies. ECCS will support the integration and networking of intelligent systems at the nano, micro and macro scales for a variety of application domains in healthcare, environment, energy, communications, disaster mitigation, homeland security, transportation, manufacturing, and other systems-related areas. ECCS envisions a research community that will address major technological challenges for the next generation of devices and systems due to convergence of technologies and increased emphasis on interdisciplinary research to achieve the goals of the American Competitiveness Initiative and the America COMPETES Act. ECCS will integrate education into its research programs to ensure the preparation of a diverse workforce for the 21st century that can enable innovative advances in emerging technologies as drivers of the global economy.

ECCS is organized around three programs: Electronics, Photonics and Device Technologies; Power, Controls and Adaptive Networks; and Integrative, Hybrid and Complex Systems, which will focus on research and educational issues of device and component technologies, network and computational technologies, and systems engineering.

In general, 70 percent of the ECCS funds are available for new research grants; the remaining 30 percent funds continuing grants made in prior years.

ECCS Priorities for FY 2009:

The Electronics, Photonics and Device Technologies (EPDT) program will seek to improve the fundamental understanding of devices and components based on the principles of electronics, photonics, magnetics, organics, electro-optics, electromechanics, and related physical phenomena at the nanoscale. The program will enable discovery and innovation in advancing the frontiers of spin electronics, molecular electronics, bioelectronics, nonsilicon electronics, flexible electronics, optoelectronics, microwave photonics, power electronics, and mixed signal devices. EPDT will further support related topics in quantum engineering, novel electromagnetic materials-based devices, radio-frequency integrated circuits, and reconfigurable antennas for communications, telemedicine and other wireless applications.

The program will continue cooperative efforts with the semiconductor industry on new nanoelectronics concepts beyond the scaling limits of silicon technology. EPDT will provide additional emphasis on emerging areas of diagnostic and implantable devices, and will continue its support for manipulation and measurement with nanoscale precision through new approaches to instrumentation.

The Power, Controls and Adaptive Networks (PCAN) program will invest in the design and analysis of intelligent and adaptive engineering networks, including sensing, imaging, controls, and computational technologies for a variety of application domains. PCAN will further invest in adaptive dynamic programming, brain-like networked architectures performing real-time learning, cognitive and neuromorphic engineering, telerobotics and systems theory. PCAN will place strong emphasis on energy scavenging and alternative energy technologies, critical infrastructure aspects of electric power networks and grids including generation and integration of renewable, sustainable and distributed energy systems and associated high-power electronics, and interdependencies of critical infrastructure in power and communications. PCAN will also provide additional emphasis on quantum and molecular modeling and simulation of devices and systems.

The Integrative, Hybrid and Complex Systems (IHCS) program is intended to spur visionary systems-oriented activities in collaborative research and education environments for multidisciplinary integrative activities. IHCS will offer new challenges at nano/micro/macro levels of systems integration with engineering solutions for a variety of domain-specific applications. The program will support innovative research in nano/microsystems, communications systems, and cyber systems that integrate physical devices and components with controls, computational intelligence and networks. IHCS will also support integration technologies at intra- and inter-chip levels that target new communication system architectures, radio-frequency and optical wireless and hybrid communications systems, and mixed-signal systems. ECCS is committed to supporting the development of innovative hardware, signal processing, and software architectures for emerging areas of cyber systems for design, integration, and implementation of multi-scale and multi-level complex systems that will enable visualizing, analyzing, and reconfiguring of emergent-behavior for various applications. To leverage cyber-enabled discovery and innovation, IHCS will continue its support in the areas of high-performance computing to analyze and simulate the behavior of complex systems at the macroscale, and engineering virtual organizations to improve collaboration, archiving and sharing of data, and disseminating open-source software tools.

ECCS will continue to provide support for specialized resources and infrastructure that facilitate research and educational activities, as well as crosscutting activities. ECCS will support the development of people through Foundation-wide programs, such as CAREER and ADVANCE, and through REU and RET supplements, and will actively participate in the development and management of cross-disciplinary programs including small teams.

Changes from FY 2008:

- Support increases by $1.99 million for the CDI NSF-wide investment.
- Support of $1.60 million for the SEBML NSF-wide investment.
- $1.0 million in support of the AST NSF-wide investment.
- Support of $120,000 for the WATER NSF-wide investment.
- Support increases by $190,000 for Nanoscale Science & Engineering Centers
- An increase of $6.63 million to support leading edge, frontier research in core programs and in support of the Engineering research themes.
- Decreases support by $670,000 for the Science and Technology Center.

INDUSTRIAL INNOVATION AND PARTNERSHIPS $140,900,000

The FY 2009 Budget Request for the Industrial Innovation and Partnerships (IIP) Division is $140.90 million, an increase of $19.23 million, or 15.8 percent, over the FY 2008 Estimate of $121.67 million.

Industrial Innovation and Partnerships Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Industrial Innovation and Partnerships	**$120.78**	**$121.67**	**$140.90**	**$19.23**	**15.8%**
Major Components:					
Small Business Innovation Research (SBIR)	97.20	97.85	113.62	15.77	16.1%
Small Business Technology Transfer (STTR)	11.47	11.52	13.38	1.86	16.1%
Grant Opportunities for Academic Liaison with Industry (GOALI)	5.51	5.60	6.33	0.73	13.0%
Industry/University Cooperative Research Centers (I/UCRC)	6.60	6.70	7.57	0.87	13.0%

About IIP:

The Division of Industrial Innovation and Partnerships serves the entire Foundation by fostering partnerships aimed at advancing technological innovation. The division is organized to respond to the American Competitiveness Initiative (ACI) and the America COMPETES Act by catalyzing the transformation of discovery into societal benefits through stimulating partnerships for innovators. IIP is home to two legislatively mandated small business research programs, the Small Business Innovation Research program (SBIR) and the Small Business Technology Transfer program (STTR). Additionally, IIP leverages industrial support through two research programs, Industry/University Cooperative Research Centers (I/UCRCs) and Grant Opportunities for Academic Liaison with Industry (GOALI) programs.

Twice each year, SBIR and STTR release proposal solicitations containing topics targeted to innovative small businesses in the United States. These solicitations cover technologies that emphasize innovation with commercialization potential. From the business community perspective, SBIR/STTR investments are considered "pre-seed." That is, they support research that is considered too high-risk for even early stage corporate investment. The research topics in the SBIR/STTR solicitations are designed to meet the needs of capital/investment markets, strategic partners, and national and societal priorities. They also have the potential to encourage new venture and business investments outside of the SBIR/STTR program.

The Industry/University Cooperative Research Centers (I/UCRC) program develops long-term partnerships among industry, academe, and government. The centers are catalyzed by a small investment from NSF, and are primarily supported by industry center members, with NSF taking a supporting, guiding role in their development and evolution. Each center is established to conduct research that is of interest to both the industry and the center. An I/UCRC contributes to the nation's innovation infrastructure base and enhances the intellectual capacity of the engineering and science workforce through the integration of research and education.

The Grant Opportunities for Academic Liaison with Industry (GOALI) program enables partnerships between industry and academe where there is a common intellectual, educational, and innovation agenda.

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, focusing on high-risk topics that would not otherwise be undertaken by industry. It enables development of innovative, collaborative university/industry educational programs, and the direct exchange of new knowledge between academe and industry.

IIP Priorities for FY 2009:

Within the SBIR/STTR research topics, Biotechnology, Information Technology, and Electronics Technology are positioned to potentially attract venture capital and "angel network" communities. Advanced Materials and Manufacturing and Chemical Technology research topics are of interest to the large corporations that see the potential for strategic partnerships with the small business community. Selected topics are launched in response to national priorities such as Manufacturing Innovation and Security Technology. To accelerate near term technological innovation, a special topic, Emerging Opportunities, and a supplement to qualifying Phase I grantees, were launched in 2006. Starting in FY 2006, SBIR and STTR programs reversed the downward trend in funding rate from a low of 14 percent by controlling release of solicitation topics. With increased funding in 2008, the target is to achieve a 20 percent funding rate.

The 47 I/UCRCs work closely with industry to develop enabling technologies needed to manage the electrical power system, improve manufacturing and biological processes, develop new materials, improve information and telecommunications technologies, and innovate new products and services. The I/UCRC program provides modest seed funds and management expertise to these highly leveraged centers, with states joining in many partnerships to expand the centers' activities to impact local economic development. The I/UCRC program also supports a supplemental research initiative to advance the underlying innovation potential of the centers. Currently, the I/UCRC and SBIR/STTR programs are exploring synergistic academic-small business partnership opportunities as a model to accelerate the innovation process.

The strategic plan for the Directorate for Engineering calls for increasing partnerships between academic and industrial communities. GOALI is well positioned to directly impact this objective. GOALI leverages its budget with support from other academic research programs by a factor of four-to-one. In FY 2009, the GOALI program will seek opportunities to accelerate innovation, strengthening the discovery knowledge base for a quicker transformation of discovery to societal benefit.

Changes from FY 2008:

- Increase of $15.77 million, to a total of $113.62 million for the Small Business Innovation Research program.
- Increase of $1.86 million, to a total of $13.38 million for the Small Business Technology Transfer program.
- Funding increases $870,000, to a total of $7.57 million for the I/UCRC program.
- Increase of $730,000, to a total of $6.33 million for GOALI program.

ENGINEERING EDUCATION AND CENTERS $119,850,000

The FY 2009 Budget Request for the Engineering Education and Centers (EEC) Division is $119.85 million, an increase of $3.96 million, or 3.4 percent, over the FY 2008 Estimate of $115.89 million.

Engineering Education and Centers Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Engineering Education and Centers	**$115.16**	**$115.89**	**$119.85**	**3.96**	**3.4%**
Major Components:					
Research and Education Grants	55.28	49.68	52.95	3.27	6.6%
Engineering Research Centers (ERC)	47.05	52.86	53.55	0.69	1.3%
Nanoscale Science and Engineering Centers (NSEC)	9.48	10.00	10.00	-	-
Network for Computational Nanotechnology	3.35	3.35	3.35	-	-

About EEC:

The Engineering Education and Centers (EEC) Division promotes and facilitates university research and curricula by supporting innovative programs that integrate research and education, improve the quality of the engineering workforce, cut across disciplines, and enable a breadth of investigation that spans from idea inception to proof-of-concept. The division's programs are divided into three major categories: development of interdisciplinary research centers that foster partnerships between academe, government and industry; advancing graduate and undergraduate engineering education; and development of a diverse and capable technical workforce. EEC programs address issues that are critical to all fields of engineering and benefit from a centralized management focus, as well as complement the research and education portfolios of the other divisions of the Directorate for Engineering. Included programs benefit from a scope encompassing all of engineering and a scale that both facilitates the incorporation of new scientific knowledge into engineering and requires rigorous monitoring and evaluation systems.

In general, 79 percent of the EEC portfolio is used to fund centers, graduate fellowships, and undergraduate programs. Approximately 21 percent of the EEC portfolio is available for new research grants.

EEC Priorities for FY 2009:

In FY 2009, EEC will provide support for Engineering Research Centers, Nanoscale Science and Engineering Centers, engineering education research, and engineering workforce development.

In FY 2009, 15 Engineering Research Centers will receive funding. Examples of center research include: research and development of sensory prostheses that interface to the human nervous system, systems for detection of and warning for severe storms, computer-integrated surgical systems, biomaterials for implants, reconfigurable manufacturing systems, and power electronics. In FY 2008, EEC is planning to add five new ERCs to the portfolio through the graduation to self-sufficiency of existing ERCs, and through the phasing down of support to others during FY 2006 and 2007 to prepare them for self-sufficiency.

The eight ongoing Nanoscale Science and Engineering Centers, fully or partially supported by EEC, perform research to advance the development of the ultra-small technology that will transform electronics, materials, medicine, and many other fields. They involve key partnerships with industry, national laboratories, and other sectors; and support education programs from the graduate to the pre-college levels designed to develop a highly skilled workforce. Funds are also provided to smaller interdisciplinary teams and to the Network for Computational Nanotechnology (www.nanHub.org), a web-accessible repository of simulations of nanoscale phenomena for research and education.

EEC programs in engineering education are aimed at transforming engineering education to produce an engineering workforce that is diverse and creative, understands the impacts of its solutions on both technical and social systems, and possesses the ability to adapt to the rapidly evolving technical environment in industry, academe, and society. In FY 2009, research will be supported to improve the development, management, and productivity of quality engineering education at both the undergraduate and graduate levels. Significant breakthroughs in understanding are sought so that our undergraduate and graduate engineering education can be transformed to meet the needs of the changing economy and society. Topics of particular interest include: the aims and objectives of engineering education, the content and organization of the curriculum, how students learn problem solving, how to encourage creativity and design, developing new methods for assessment and evaluation of how students learn engineering, understanding the business aspect of engineering education, and conducting research that helps us understand how to attract and retain a more talented and diverse student body to all levels of engineering study.

Existing programs in Research Experiences for Undergraduates (REU) Sites and Research Experiences for Teachers (RET) Sites, which have been shown to be successful programs for broadening participation in engineering programs at both the undergraduate and graduate levels, will increase in FY 2009.

Changes from FY 2008:

- Support for the Research and Education Grants increases by $3.27 million, to a total of $52.95 million.
- Funding for ERCs increases by $690,000, to a total of $53.55 million.

EMERGING FRONTIERS IN RESEARCH AND INNOVATION $29,000,000

The FY 2009 Budget Request for the Office of Emerging Frontiers in Research and Innovation (EFRI) is $29.0 million, an increase of $4.0 million, or 16.0 percent, over the FY 2008 Estimate of $25.0 million.

Emerging Frontiers in Research and Innovation Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Emerging Frontiers in Research and Innovation	**25.25**	**$25.00**	**$29.00**	**$4.00**	**16.0%**

About EFRI:

The Office of Emerging Frontiers in Research and Innovation (EFRI) resides within the Office of the Assistant Director for Engineering and was established in FY 2007 to fulfill the critical role of helping ENG focus on important emerging areas in a timely manner. Each year EFRI recommends, prioritizes, and funds interdisciplinary topics at the emerging frontier of engineering research and education. These emerging frontiers are frequently found in transformative interdisciplinary areas. The divisions within the NSF's Engineering Directorate are not strategically aligned to support this type of research, which often falls outside the usual classifications and research areas. EFRI enables ENG to pursue these interdisciplinary areas by allowing the engineering community to come forward with new and paradigm-shifting proposals at the interface of disciplines and fields.

Technological innovations, particularly over the past decade, have given rise to new industries, expanded our access to quality healthcare, and fueled our nation's prosperity even in the face of growing global competition. Now that global competition is increasing, the technical underpinnings of the past may not be adequate to ensure our continued success. EFRI will provide critical, strategic support of fundamental discovery, particularly in areas leading to breakthrough technologies.

EFRI investments represent transformative opportunities, potentially leading to: new research areas for NSF and other agencies; new industries or capabilities that result in a leadership position for the country; and/or significant progress on a recognized national need or grand challenge. These challenges may include areas such as safe, clean water; sustainable energy resources; technologies to overcome physical limitations from disease or injury; and integrated systems designed to thwart attacks on U.S. infrastructures and interests throughout the world. EFRI will have the necessary flexibility to target our long-term challenges, while retaining the ability and agility to adapt as new challenges demand.

In general, 100 percent of the EFRI portfolio is available for new research grants.

EFRI Priorities for FY 2009:

The role of the EFRI Office is to fund research opportunities that would be difficult to fund with current mechanisms, such as Small Grants for Exploratory Research, typical core awards, or large research center solicitations. The successful topics would likely require small- to medium-sized interdisciplinary teams of researchers with significant funding, for a period of time needed to make substantial progress that would provide evidence for additional follow-on funding through other established funding mechanisms.

Mechanisms: Potential EFRI topics can arise from input from a number of sources: the community, advisory committees, workshops, professional societies, academies, proposals and awards, and NSF committees of visitors. Yet, in the case of directed specified topics, the ENG program directors will play the central role within NSF.

Potential EFRI topics will be evaluated against criteria such as: Does the topic represent an opportunity for a significant leap or paradigm shift in a research area, or have the potential to create a new research area? Is there potential for making significant progress on a current national need or grand challenge? Is the financial and research scope beyond the capabilities of one division? Is the community able to organize and effectively respond?

Example topic areas that EFRI has pursued based on the above criteria are Autonomously Reconfigurable Engineered Systems (ARES), Cellular and Biomolecular Engineering (CBE), Cognitive Optimization (COPN), and Resilient and Sustainable Infrastructures (RESIN). In ARES, researchers are paving new research frontiers for engineering systems that can modify themselves when subject to *unplanned* events. In CBE, methods and technologies are being developed to regenerate some of the body's most complex tissues. COPN will fund projects that will build new dynamic optimization algorithms by studying the way systems of neurons do such complex tasks. RESIN will fund projects to develop the theoretical foundation, methods, and technologies for making interdependent critical infrastructures both resilient and sustainable.

EFRI research in FY 2009 will better enable the Engineering Directorate to meet its strategic goal of fostering frontier and transformative research. Topics for EFRI support will typically relate to the five key ENG Themes. These are:

- *Cognitive Engineering*, which focuses on the intersection of engineering and cognitive science;
- *Competitive Manufacturing and Service Enterprises*, which includes research that catalyzes multiscale manufacturing, from fundamental metrology to new knowledge for realizing atomic-scale control of raw materials and systems;
- *Complexity in Engineered and Natural Systems*, which addresses unifying principles that enable modeling, prediction, and control of emergent behavior in complex systems;
- *Energy, Water and the Environment*, which focuses on an integrative approach to understanding interconnections among energy, water, and the environment; and includes frontier research to improve the cost, sustainability, and security of our nation's energy system; and
- *Systems Nanotechnology*, which is the next frontier in nanotechnology. This research will help to create controllable systems built from nanoscale components and help in understanding interactions among nanostructures and their collective behavior in systems. Goals are discoveries and innovation for new industrial and medical applications.

These frontier research areas will guide the decision-making process throughout the Engineering Directorate, but specifically within the Office of Emerging Frontiers in Research and Innovation.

Changes from FY 2008:

The additional $4.0 million will allow for the support of 14 awards, rather than 12, to strengthen the impact of this important office.

GEOSCIENCES $848,670,000

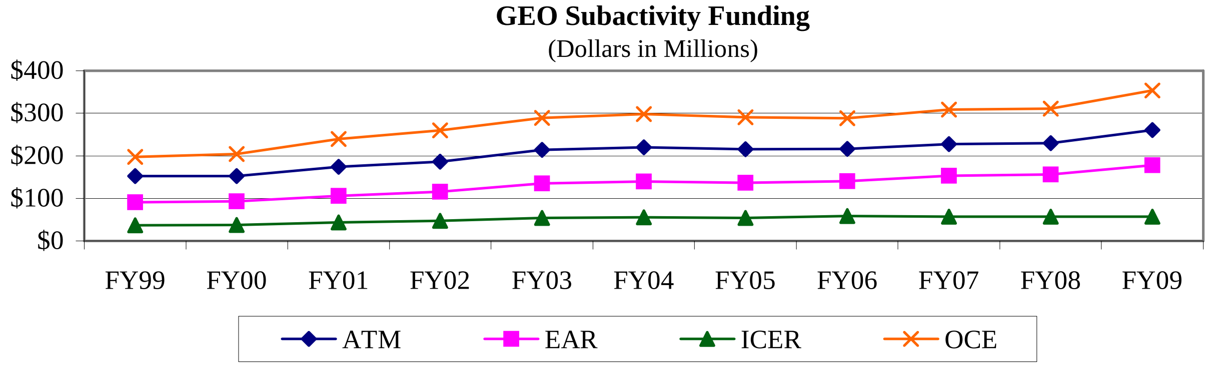
The FY 2009 Budget Request for the Directorate for Geosciences (GEO) is $848.67 million, an increase of $96.01 million, or 12.8 percent, over the FY 2008 Estimate of $752.66 million.

Geosciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change Over FY 2008 Estimate Amount	Change Over FY 2008 Estimate Percent
Atmospheric Sciences (ATM)	227.44	229.30	260.58	31.28	13.6%
Earth Sciences (EAR)	152.83	156.08	177.73	21.65	13.9%
Innovative & Collaborative Education & Research (ICER)	56.82	56.82	56.82	-	-
Ocean Sciences (OCE)	308.76	310.46	353.54	43.08	13.9%
Total, GEO	$745.85	$752.66	$848.67	$96.01	12.8%

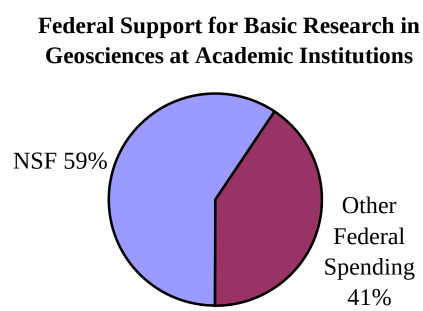
Totals may not add due to rounding.

As the principal source of federal funding for university-based fundamental research in the geosciences, the Directorate for Geosciences addresses the Nation's need to understand, predict, and respond to environmental events and changes. GEO-supported research also advances our ability to predict natural phenomena of economic and human significance, such as climate changes, hurricanes, fish-stock fluctuations, earthquakes, and disruptive events in the solar-terrestrial environment. **GEO is NSF's lead partner in the U.S. Global Change Research Program, and plays a critical role in advancing our understanding of the basic drivers of global environmental change and the Earth's responses.**



RELEVANCE

GEO provides about 59 percent of the total federal funding for university-based, basic research in the geosciences. In addition to playing a critical role in addressing the Nation's need to understand, predict, and respond to environmental events and changes, GEO also helps to determine the best use of Earth's resources. Fundamental research in the geosciences advances scientific knowledge of resources such as fresh water, energy, minerals, and biological diversity, leading to improved future quality of life. GEO



investments include many environmental studies coordinated through the U.S. Climate Change Science Program. GEO supports many national and global observational facilities and other research infrastructure for land, ocean, and atmospheric processes.

GEO supports basic research that advances the frontiers of knowledge and drives technological innovation while improving our understanding of the many processes that affect the global environment. These processes include the role of the atmosphere and oceans in climate, the planetary water cycle, and ocean acidification. Support is provided for interdisciplinary studies that contribute directly to national research priorities: hydrologic systems, biogeochemical dynamics, ecological systems and dynamics, solid earth processes, and solar influences on the Earth system. Lives are saved and property is preserved through better prediction and understanding of natural environmental hazards such as earthquakes, tornados, hurricanes, tsunamis, drought, and solar storms. Basic research supported by GEO enables preparation for and subsequent mitigation of or adaptation to the effects of these and other disruptive natural events. Associated with these studies is the need for databases and cyberinfrastructure to provide the scientific community with the resources to assemble and utilize data and information efficiently and effectively, consistent with the Administration's priorities for research and development.

GEO supports research and education in a variety of areas that are consistent with the American Competitiveness Initiative. Many fields within the geosciences focus on physics in the environment – solar-terrestrial interactions and the complex interplay of forces in the Earth's core that creates the Earth's magnetic field, for example – and other areas such as integrated water cycle science and studies of climate change are of tremendous relevance with potentially huge economic benefits. Further, activities supported by GEO are well-aligned with the Administration's research and development priorities, including investments in high-end computing, improving our ability to understand and respond to global environmental issues, and improving quality of life. Finally, geoscience research directly contributes to NSF's priority of fostering research that improves our ability to live sustainably on Earth.

GEO will coordinate with other federal agencies and the science community to implement both near-term and longer-term goals as articulated in the Ocean Research Priorities Plan. In particular, near-term interagency studies will emphasize forecasting the responses of coastal ecosystems to persistent forcing and extreme events and the development of new marine ecosystem sensors for measurement of biological, physical, and chemical properties of the ocean. Also important will be comparative analysis of marine ecosystem organization and a robust assessment of the variability of the Atlantic meridional overturning circulation and its implications for rapid climate change.

Two critical areas receiving increased emphasis in FY 2009 are the NSF-wide activities Dynamics of Water Processes in the Environment and Cyber-enabled Discovery and Innovation (CDI). Science has advanced to the point that it is now possible to examine terrestrial water as a dynamic system rather than as the aggregate of discrete components. In FY 2009, the focus of GEO's investment will be to define frontier research opportunities, delineate NSF's leadership role in this area and advance activities in foundational water systems research. This investment will create the scientific basis for analytical models that can anticipate fresh water needs and availability under a variety of human-forced scenarios and as mediated by climate change. GEO's investment in CDI will focus on the development of the next generation of computationally-based discovery concepts and tools to deal with data-rich and interacting systems.

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, GEO $752.66

Atmospheric Sciences (ATM) +31.28

Increased support will augment research to understand and predict environmental extreme events and to understand the effects of biogeochemical cycles. Increased support will also be provided for advanced cyberinfrastructure and numerical models; and to increase participation in key interagency such as the US Climate Change Science Program, the U.S. Weather Research Program and the National Space Weather Program. Support for atmospheric observing facilities and the National Center for Atmospheric Research will increase to enable expansion of activities related to climate modeling and provision of world-class ground, airborne, and space-borne observational facilities and services.

Earth Sciences (EAR) +$21.65

Increased funding is focused on operational and scientific support of the EarthScope facility. Research support in EAR will also increase, with emphasis on support for theoretical research, including the biological geosciences, the hydrologic sciences and the study of natural hazards, such as earthquakes and volcanic eruptions. The final year of construction funding for EarthScope was appropriated through the Major Research Equipment and Facilities Construction (MREFC) account in FY 2007, although construction activities will continue through FY 2008.

Innovative & Collaborative Education and Research (ICER) +$0.00

In FY 2009, support for international collaborative activities and other cross-directorate programs will remain level, enabling continued international collaborations, maintenance of crosscutting diversity and education programs, and programs focused on integrated earth systems research.

Ocean Sciences (OCE) +$43.08

Areas receiving increased funding support include developmental activities related to the Ocean Observatories Initiative, operation of the Academic Research Fleet, and operational support for the Integrated Ocean Drilling Program. Increased support will also target the near-term research priorities of the Ocean Research Priorities Plan, emerging trends in the biogeochemical cycles, and paleoperspectives on climate change.

Subtotal, Changes +$96.01

FY 2009 Request, GEO.. $848.67

Summary of Major Changes in Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, GEO $752.66

<u>Discovery</u> +$46.40

Cyber-enabled Discovery and Innovation (+$3.42 million).

Investment in CDI seeks to infuse computational thinking into all areas of the geosciences, bringing computational capabilities into the traditional experimentation-observation-analysis-theory research paradigm. GEO's investment in CDI will focus on the development of the next generation of computationally-based discovery concepts and tools to deal with data-rich and interacting systems.

Dynamics of Water Processes in Earth's Environment (+$5.26 million).

Initial GEO funding of funding of $5.26 million in FY 2009 will focus on defining frontier research opportunities, delineating NSF's leadership role in this area and advancing activities in foundational water systems research, establishing open access data systems, and mining data for essential scientific information.

Ocean Research Priorities Plan (+$12.0 million).

Responding to the Ocean Research Priorities Plan (ORPP), GEO will support highly meritorious proposals addressing both the near-term and long-term priorities articulated in the ORPP.

Disciplinary and Interdisciplinary Research (+$24.77 million).

GEO investments in fundamental research will continue to advance the frontiers of knowledge and discovery by working across traditional boundaries and encouraging multidisciplinary, transformative, and high-impact research. Contributing to American technical innovation and scientific leadership, these investments directly address government-wide research and development priorities, particularly those related to innovation; understanding global and regional environmental issues, such as adaptation and mitigation to climate change; natural disasters; and improving the future quality of life.

Centers (-$50,000).

In FY 2009, several changes to centers support are planned. Beginning in FY 2009, GEO will partially support, at $250,000, a center on nano-related environment, safety, and health. Also, support for a Science and Technology Center (STC) started in FY 2000 will ramp down as planned toward sunset in FY 2009.

CAREER (+$1.0 million).

Support for NSF's premier award for early career investigators will increase by $1.0 million.

<u>Learning</u> +$0.48

Integrative Graduate Education and Research Traineeships (IGERT) (+$80,000).

An increase of $80,000 to a total of $3.47 million will enable the support of additional participants in this important cross-Foundation program.

Research Experiences for Undergraduates (+$400,000).

Support for both REU supplements and sites will be augmented, enabling the support of approximately 50 additional student participants.

Research Infrastructure +$46.33

Academic Research Fleet (+$13.30 million).

GEO is the primary supporter of operations of the national Academic Research Fleet. An increase of $14.8 million, to a total of $87.96 million, will augment support of ship operations and provide a number of enhancements to the academic fleet.

Within this amount, an increase of $6.80 million to a total of 72.96 million will enable NSF-supported researchers to conduct research in the world's oceans. FY 2009 is planned as the start of a series of up to three Regional-class Research Vessel acquisitions ($10.0 million, an increase of $8.50 million over the FY 2008 Estimate) to move beyond the design phase and begin construction of ships to replace aging and less capable ships. Replacement Human Occupied Vehicle (RHOV) construction continues at a level of $1.0 million.

EarthScope Operation (+$8.68 million).

Operational support of the EarthScope facility funded through GEO is $26.29 million in FY 2009, an increase of $8.68 million over the FY 2008 Estimate, enabling operation of the completed facility. The final year of construction funding for EarthScope was appropriated through the MREFC account in FY 2007, although construction activities will continue through FY 2008.

Incorporated Research Institutions for Seismology (IRIS) Operation (+$450,000).

Operational support of the IRIS facility will total $12.2 million, a $450,000 increase over the FY 2008 Estimate. This increase will enable the repair, and upgrade of seismic stations and instrument replacements.

Ocean Drilling Activities (+$8.48 million).

The Integrated Ocean Drilling Program (IODP), including operation of the Scientific Ocean Drilling Vessel (SODV) acquired and outfitted with support from the MREFC account, will increase overall by $8.48 million to a total of $47.74 million. FY 2009 represents the first fiscal year the refurbished drillship will be fully available to the program after extensive shipyard work.

Ocean Observatories (+$1.5 million).

Support for activities to prepare for the Ocean Observatories Initiative, one of GEO's contributions to the Global Earth Observation Systems of Systems (GEOSS) will increase to enable continued planning.

National Center for Atmospheric Research (NCAR) (+$9.0 million).

NCAR is a Federally Funded Research and Development Center (FFRDC) supported by NSF and other federal agencies to provide facilities and support for a wide range of studies in the atmospheric and related sciences. In FY 2009, GEO support for NCAR will increase by $9.0 million, to a total of $95.42 million to: accelerate efforts in provide robust, accessible, and innovative information services and tools to the community; enhance NCAR's ability to provide to researchers world-class ground, airborne, and space-borne observational facilities and services; increase our understanding of societal resilience to weather, climate, and other atmospheric hazards; and increase efforts to cultivate a scientifically literate and engaged citizenry and a diverse and creative workforce.

Research Resources (+$4.82 million).

Support for community instruments and databases, including the University Navstar Consortium (UNAVCO), a number of radar facilities to study processes in the upper atmosphere, and many small instruments supported for research community use will increase by $4.82 million to a total of $64.16 million.

Other Research Infrastructure (+$100,000).

Support for the National Astronomy and Ionosphere Center (NAIC) will be augmented slightly to enable Geoscience activities at this facility to continue at a comparable level to FY 2008.

<u>Stewardship</u> +$2.80

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$97.05

FY 2009 Request, GEO.. $848.67

GEO Facilities Funding

(Dollars in Millions)

Facilities	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Academic Research Fleet	$87.94	$70.66	$83.96	$13.30	18.8%
Regional Research Vessel	*1.57*	*1.50*	*10.00*	*8.50*	*566.7%*
RHOV Construction (R/V Alvin Replacement)	*9.05*	*1.00*	*1.00*	-	-
R/V Langseth Construction (R/V Ewing Replacement)	*0.69*	*2.00*	-	*-2.00*	*-100.0%*
Ship Operation and Upgrade	*76.63*	*66.16*	*72.96*	*6.80*	*10.3%*
EarthScope: USArray, SAFOD, PBO	11.63	17.61	26.29	8.68	49.3%
Incorporated Research Institutions for Seismology	11.77	11.75	12.20	0.45	3.8%
Integrated Ocean Drilling Program (IODP)	34.71	39.26	47.74	8.48	21.6%
Nanofabrication (NNIN)	0.50	0.50	0.50	-	-
Ocean Observatories	6.49	9.00	10.50	1.50	16.7%
NCAR	85.12	86.42	95.42	9.00	10.4%
NAIC	-	1.70	1.80	0.10	5.9%
Total, GEO	$238.15	$236.90	$278.41	$41.51	17.5%

Totals may not add due to rounding.

NSF-WIDE INVESTMENTS

In FY 2009, the Directorate for Geosciences will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

GEO Funding for NSF-Wide Investments
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change Over FY 2008 Estimate Amount	Percent
Biocomplexity in the Environment	$26.1	-	-	-	n/a
Climate Change Science Program	157.7	157.7	164.7	7.0	4.4%
Cyber-enabled Discovery & Innovation	-	1.0	4.4	3.4	342.0%
Cyberinfrastructure	75.0	75.0	80.0	5.0	6.7%
Dynamics of Water Processes in the Environment	-	-	5.3	5.3	n/a
Human & Social Dynamics	1.4	1.4	-	-1.4	-100.0%
International Polar Year	5.7	5.0	-	-5.0	-100.0%
Mathematical Sciences	5.8	-	-	-	n/a
National Nanotechnology Initiative	9.7	9.7	6.3	-3.3	-34.4%
Networking & Information Technology R&D	14.6	15.6	19.0	3.4	22.0%

Biocomplexity in the Environment: With the conclusion of this priority area in FY 2007, key components of investment in Biocomplexity in the Environment will be transferred to core programs for continued support, with selected aspects such as studies of biogeochemical cycles being revitalized.

Climate Change Science Program (CCSP): GEO leads NSF efforts in the interagency CCSP to enhance understanding of the dynamics among natural and human systems, generate the knowledge needed to preserve, manage, and enhance the environment, as well as to support national and international policy-making activities. Directly contributing to the Administration's R&D priorities, specific activities include programs focused on understanding past climate variability, elucidating how carbon and nitrogen cycle through the earth, atmosphere, and oceans, and efforts to develop and refine computational models of Earth system processes. In FY 2009, increased emphasis will be placed on understanding the Earth's water cycle and on climate-driven aspects of disruptive environmental events, such as hurricanes and severe storms.

Cyber-enabled Discovery and Innovation: Investments in CDI seek to infuse computational thinking into all areas of the geosciences, bringing computational capabilities into the traditional experimentation-observation-analysis-theory research paradigm. GEO's investment in CDI will focus on the development of the next generation of computationally-based discovery concepts and tools to deal with data-rich and interacting systems.

Cyberinfrastructure (CI): GEO cyberinfrastructure investment supports the development of IT-based research infrastructure for disciplines across the geosciences. One flagship activity is the Climate Simulation Laboratory at NCAR, located in Boulder, CO, which serves a broad community of researchers utilizing advanced computational techniques to model atmospheric processes ranging from projections of future climate to forecasting hurricane intensity and landfall.

Dynamics of Water Processes in the Environment: Science has advanced to the point that it is now possible to examine terrestrial water as a dynamic system rather than as the aggregate of discrete components. In FY 2009, the focus of this investment will be to define frontier research opportunities, delineate NSF's leadership role in this area and advance activities in foundational water systems research. This investment will create the scientific basis for analytical models that can anticipate fresh water needs and availability under a variety of human-forced scenarios and as mediated by climate change.

Human and Social Dynamics (HSD): With the conclusion of this priority area in FY 2008, the collaboration between social scientists and geoscientists will continue informally through ongoing research programs.

International Polar Year (IPY): With the conclusion of IPY in March 2009, components of the investment will be transferred to core programs for continued support.

Mathematical Sciences: With the conclusion of this priority area in FY 2007, the collaboration between mathematicians and geoscientists will continue informally through ongoing research programs.

National Nanotechnology Initiative (NNI): Nanotechnology is recognized as one of the current frontiers of innovation, and is specifically linked to the ACI. Contributing to NNI, GEO will support studies of natural nanoscale processes in the environment and utilize nanoscale phenomena as catalysts for environmental remediation.

Networking and Information Technology Research and Development (NITRD): Investments in this area advance the state-of-the-art in computing and information technology, and support the development of a worldclass computing workforce and a broader IT-savvy workforce. Within NITRD, an area which explicitly supports the Administration's agency-wide R&D priorities, GEO focuses on the development and enhancement of computational modeling capacity and capability.

QUALITY

GEO maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. The share of basic and applied research funds that were allocated to projects that undergo merit review was 77 percent in FY 2007, the last year for which complete data exist. OMB's definition of competitive, merit-based review, however, does not include Federally Funded Research and Development Centers. Therefore, support for the National Center for Atmospheric Research, although regularly merit-reviewed, is not considered as funding that undergoes competitive, merit-based review for this calculation. If included, the merit-reviewed share of GEO funding would rise to 88 percent.

To ensure the highest quality in processing and recommending proposals for awards, GEO convenes Committees of Visitors, composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. In FY 2009, GEO will convene COVs for the University Corporation for Atmospheric Research (UCAR) and the Lower Atmospheric Facilities Oversight Section of the ATM Division, the Ocean Section of the OCE Division, and the Marine Geosciences Section of the OCE Division. In FY 2008, GEO will convene COVs for the Upper Atmospheric Facilities Section of the ATM Division, the Surface Earth Processes Section and the Deep Earth Processes Section in the EAR Division, and the Integrative Projects Section in the OCE Division. COVs were convened for the Lower Atmospheric Research Section of the ATM Division, the Instrumentation and Facilities Program in the EAR Division and GEO's Education and Diversity Programs in FY 2007.

The Directorate receives advice from the Advisory Committee for Geosciences (AC/GEO) on such issues as: the mission, programs, and goals that can best serve the scientific community; how GEO can promote quality graduate and undergraduate education in the geosciences; and priority investment areas in geoscience research. The AC/GEO meets twice a year and members represent a cross section of the geosciences, with representatives from many different sub-disciplines within the field; a broad range of academic institutions and industry; broad geographic representation; and balanced representation of women and under-represented minorities.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Geosciences
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Discovery	$404.91	$419.00	$471.30	$52.30	12.5%
Learning	33.18	30.26	30.74	0.48	1.6%
Research Infrastructure	300.00	295.65	336.07	40.42	13.7%
Stewardship	7.75	7.75	10.55	2.80	36.1%
Total, GEO	$745.84	$752.66	$848.67	$96.01	12.8%

Totals may not add due to rounding.

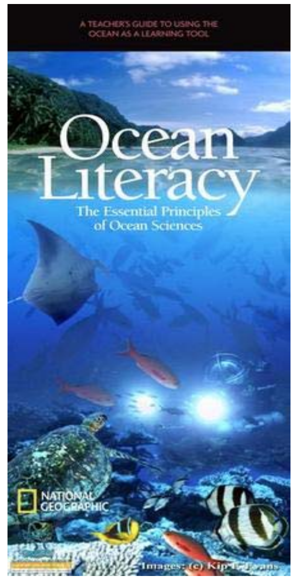
GEO will continue its commitment to education, training, and increasing diversity in FY 2009. The FY 2009 Request will permit an increase in average award size and allow GEO to continue to focus on multidisciplinary research activities, inter-agency partnerships, and international activities with special attention given to broadening participation at all levels. In addition, the sustaining of existing infrastructure and the development of new infrastructure remain priorities, with ongoing support for the acquisition of new regional research vessels and increased support for ship upgrades, the Ocean Drilling Activities program and the operation of the EarthScope facility being constructed through the MREFC account.

Recent Research Highlights

► **Scientists Explain Source of Tiny Tremors Emanating from Fault Zones:** Tiny earthquakes, discovered in fault zones from California to Japan, may foreshadow catastrophic events. NSF-supported seismologists say these findings may be useful in understanding potentially destructive mega-quakes of magnitude 8 or higher. They found that non-volcanic tremors are often accompanied by low-frequency earthquakes – small quakes of magnitude 1 or 2. Recent studies suggest that giant quakes are preceded by a series of much deeper events called slow (or silent) earthquakes, which displace the ground without shaking it. A slow earthquake can last days, months, or years without being felt at the surface. The insight may open new avenues of research for predicting earthquake hazards by using low-frequency earthquakes as indicators. It could lead to an improved ability to forecast a major earthquake. (EAR)

Entire buildings tilt because of ground failure after the Niigata, Japan, earthquake. *Credit: NGDC.*

► **Developing Ocean Literacy:** The often devastating consequences of hurricanes and tsunamis, and the even larger-scale consequences of global climate change, ocean acidification, and the collapse of commercial fisheries, illustrate the powerful role that ocean processes play in shaping the human condition. Preventing or mitigating these consequences requires that ocean scientists, educators, and policy makers work together so that informed choices are made for the common good.



The Ocean Literacy Initiative. *Credit: Copyright Kip F Evans.*

The Centers for Ocean Sciences Education Excellence (COSEEs) have been instrumental in promoting the development of ocean literacy concepts at a national scale. In June 2006, NSF co-sponsored the Conference on Ocean Literacy which brought together representatives from federal agencies, experts in formal and informal education, non-governmental organizations, and industry representatives to lay the groundwork for developing a national strategy for an ocean-literate society. The recommendations from the conference include revamping curricular standards, improving linkages between the research communities, educators, and government agencies, and fostering regional and national networks. Together, they represent a major advance in meeting the challenge of increasing public understanding of ocean processes. (OCE)

Landsat satellite image of the Salton Sea, Coachella Valley and the San Andreas fault in California. *Credit: Yuri Fialko UCSD/SIO*

► **Study Shows Southern San Andreas may be Ready for a Major Earthquake:** Yuri Fialko at the University of California, San Diego Scripps Institute of Oceanography was funded by NSF to explore the Earth's deformation in southern California, using satellite images, GPS and seismic measurements.

This research has substantially improved description and understanding of the strain building along major plate boundary faults, the southern San Andreas Fault and the San Jacinto Fault. Fialko calculated that over the last 300 years the San Andreas Fault has accumulated 6 to 8 meters of slip deficit (between 20 and 26 feet), which is close to or in excess of the maximum slip deficit ever documented for the fault. The San Jacinto Fault is straining at rates higher than other estimates, at 19-21 millimeters per year (between .75 and .83 inches per year).

In addition, a prominent feature of the strain accumulation that has not been previously recognized is that the eastern side of the faults are moving faster than the western side. The results also imply that the southern San Andreas Fault is in the late phase of seismic loading and may be primed for a significant earthquake. The researcher collaborated with the Scripps Institution of Oceanography Visualization Center to provide online, visually compelling illustrations of these recent results to a broader audience. (EAR)

► **Scientists Track Impact of Asian Dust and Pollution on Clouds, Climate Change:** Scientists are using one of the nation's newest and most capable research aircraft, HIAPER, a modified Gulfstream-V aircraft, for a far-reaching field project to study plumes of airborne dust and pollutants that originate in Asia and journey to North America. The plumes are among the largest such events on Earth, so great in scope that scientists believe they might affect clouds and weather across thousands of miles while interacting with the sun's radiation and playing a role in global climate. Known as PACDEX (Pacific Dust Experiment), the project will be led by scientists at the NSF-supported National Center for Atmospheric Research and the Scripps Institution of Oceanography. PACDEX will help scientists refine computer models of greenhouse gas emissions and improve forecasts of future climate change. (ATM)

Plumes from airborne dust and pollutants will be studied during the Pacific Dust Experiment. *Credit: NCAR..*

► **Biodiversity Loss in the Oceans Impacts Human Resources:** Marine ecosystems around the world are being impacted by multiple environmental and human pressures that result in the loss of populations and species. The effect is commonly referred to as a decrease in biodiversity. While the outcomes of these losses are difficult to understand and predict, recent research funded by NSF's Biological Oceanography Program and conducted by Emmett Duffy from the Virginia Institute of Marine Sciences, Fiorenza Micheli of Stanford University, and John Stachowicz at the University of California, Davis, and analyzed at the NSF-supported National Center for Ecological Analysis and Synthesis (NCEAS), describes both the gravity of the changes and mechanisms to remediate the current trajectories of biodiversity loss (Worm et al., 2006 Science 314: 787-790).

Landing of Codfish in the Gulf of Maine. *Credit: Massachusetts Division of Marine Fisheries.*

By conducting a large scale analysis of published data from a wide variety of coastal and oceanic ecosystems, the authors were able to discern important long-term ecological patterns. The analysis shows that increased diversity of primary producers (phytoplankton, seagrasses, etc.) and primary consumers enhanced all ecosystem processes examined, such as nutrient cycling, growth, transfer of energy through the food web, and the ability to withstand repeated disturbances such as storms or hurricanes.

Their research also revealed that biodiversity losses contribute to significant declines in fishery resources and areas used as nursery habitats for fishes. Globally, commercial fish populations have been on a long downward trend, and their ability to recover is dramatically degraded by declining biodiversity. Significantly, however, the research showed that when marine ecosystems are protected through restoration efforts or the establishment of marine protected areas (MPAs), the yield of fisheries increases. By maintaining species diversity in a wide variety of marine ecosystems, many key processes that humans have come to rely on (such as fisheries yields and pollution control) may be maintained and improved with long-term economic benefits. (OCE)

► **Northwest Atlantic Ocean Ecosystems Experiencing Large Climate-Related Changes:** Ecosystems along the continental shelf waters of the Northwest Atlantic Ocean are experiencing large, rapid changes. While some scientists have pointed to the decline of cod from overfishing as the main reason for the shifting ecosystems, researchers emphasize climate change is also playing a big role. A majority of scientists believe humans are warming the planet by burning fossil fuels and changing land surfaces, with early signs of this warming now appearing in the Arctic. Since the late 1980s, scientists have observed pulses of fresh water from increased precipitation and melting of ice on land and sea in the Arctic. This fresh water flows into the North Atlantic Ocean, making the water less salty. At the same time, climate-driven shifts in Arctic wind patterns have redirected ocean currents. The combination of these processes has led to a freshening of the seawater along the North Atlantic shelf which in turn has impacted the seasonal cycles of phytoplankton (tiny floating plants), zooplankton (tiny animals like copepods) and fish populations that live near the surface. (OCE)

The influx of fresh water from Arctic climate change is impacting seasonal fisheries and plankton. *Credit: JupiterImages.*

► **Revolutionary Satellite System Boosts Accuracy of Weather and Climate Predictions:** Preliminary findings from a novel satellite system launched earlier this year show that the system can increase the accuracy of forecasts of hurricane behavior, significantly improve long-range weather forecasts, and monitor climate change with unprecedented accuracy. The set of six microsatellites, launched in April 2006, is probing the atmosphere in ways that have been impossible with previous observing systems. The system, Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC), is based on a design provided by the University Corporation for Atmospheric Research (UCAR).

COSMIC launch from Vandenberg Air Force Base in California at 6:40 p.m. PDT (9:40 p.m. EDT) on Friday, April 14, 2006. *Credit: Photo courtesy of Orbital Sciences Corporation.*

COSMIC works by tracking tiny changes in the speed of GPS radio signals. Using these data, scientists can now produce vertical profiles of temperature and water vapor at more than 1,000 points over Earth each day, sampling the troposphere (the atmosphere's "weather layer," closest to Earth's surface) and the stratosphere. By next year, some 2,500 profiles will be produced daily. Higher up, the system measures electron density in the ionosphere, an important observation for space-weather analysis and forecasting.

In a test at the European Centre for Medium-Range Weather Forecasts, scientists added COSMIC data to the other weather observations used to kick-start computer forecast models. With the help of COSMIC data, stratospheric temperature forecasts over the Northern Hemisphere improved significantly. Predictions of hurricanes and typhoons should also benefit from COSMIC. A test involving one of the main U.S. forecast models found that the model was able to predict the birth of Hurricane Ernesto in 2006 two days in advance with COSMIC data. Without the data, the model was unable to predict Ernesto's formation. Tests in Taiwan involving Tropical Storm Bilis and other cyclones showed that COSMIC data can reduce errors in track prediction. Generating thousands of profiles each day, COSMIC data will also help scientists observe the density of high-altitude electrons associated with damaging solar storms. Until now, altitudes of peak electron density have been difficult to study and predict because forecast models have had limited data on the vertical distribution of electrons.

The $100 million COSMIC network is the product of an agreement between the American Institute in Taiwan and the Taipei Economic and Cultural Representative Office in the United States. COSMIC is known as FORMOSAT-3 in Taiwan. U.S. support for COSMIC is provided by the National Science Foundation, NASA, the National Oceanic and Atmospheric Administration, and the Office of Naval Research. The Jet Propulsion Laboratory developed the GPS receivers used in COSMIC. (EAR)

► **Science Quest: Engaging At-Risk Students:** Scientists at the University of South Carolina are leading a program designed to increase minority student participation in the geosciences using an after school program called Science Quest. In this program, University of South Carolina graduate students in science (team leaders) work with three to five 6th grade "at-risk" students in exploring a geoscience-related topic. Teams meet once a week for 1.5 hours over a period of 10-12 weeks at two parks in poor neighborhoods. Secondary goals are to expose graduate students to outreach activities, develop hands-on activities involving their research, and use geoscience equipment in middle school classrooms. (EAR)

Graduate student and middle school children working on an experiment. *Credit: Dee Albritton (Fast Forward Technology Center) and Dr. Claudia Benitez-Nelson (University of South Carolina).*

Other Performance Indicators

The tables below show the number of people benefiting from GEO funding, and trends in award size, duration, number of awards, and funding rates.

Number of People Involved in GEO Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	4,188	4,200	4,700
Other Professionals	2,934	3,000	3,400
Postdoctorates	617	600	700
Graduate Students	2,416	2,400	2,700
Undergraduate Students	1,672	1,700	1,900
Total Number of People	11,827	11,900	13,400

GEO Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	1,347	1,400	1,600
Funding Rate	31%	31%	31%
Statistics for Research Grants:			
Number of Research Grants	1,037	1,100	1,250
Funding Rate	27%	27%	28%
Median Annualized Award Size	$119,713	$120,000	$125,000
Average Annualized Award Size	$153,922	$155,000	$160,000
Average Award Duration, in years	3	3	3

ATMOSPHERIC SCIENCES $260,580,000

The FY 2009 Request for the Division of Atmospheric Sciences (ATM) is $260.58 million, an increase of $31.28 million, or 13.6 percent, over the FY 2008 Estimate of $228.7 million.

Atmospheric Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Atmospheric Sciences Research Support	$142.32	$142.88	$165.16	$22.28	15.6%
National Center for Atmospheric Research	85.12	86.42	95.42	9.00	10.4%
Atmospheric Sciences	**$227.44**	**$229.30**	**$260.58**	**$31.28**	**13.6%**
Major Components					
Research and Education Grants	104.93	105.38	125.16	19.78	18.8%
Centers Programs					
Center for Integrated Space Weather Modeling	4.00	4.00	4.00	-	-
Center for Atmospheric Process Modeling	4.00	4.00	4.00	-	-
Facilities					
National Center for Atmospheric Research (NCAR)	85.12	86.42	95.42	9.00	10.4%
Research Resources and Infrastructure	29.39	29.50	32.00	2.50	8.5%

Totals may not add due to rounding.

About ATM:

The North American continent is subject to some of the world's most severe weather. As well as the impacts of winter Pacific storms, tropical storms over the Atlantic Ocean, Caribbean Sea, or Gulf of Mexico can develop into fierce hurricanes that pound coastal regions, spawning tornadoes and producing torrential rains and floods, and resulting in large numbers of fatalities and billions of dollars in damage to property. In the upper reaches of the Earth's atmosphere, huge solar storms can damage satellites, disrupt communication and navigation systems, and cause widespread failures in the electrical power grid. The human impacts of urban pollution and extreme weather can be severe and costly. In order to improve our ability to predict and mitigate these events, we need to further our understanding of the physics, chemistry, and dynamics of the Earth's atmosphere, from the Earth's surface to the sun, on timescales ranging from minutes to millennia. We need to better understand the underlying trends, the impact of man-made changes, the complex interactions between systems, and the coupling among the atmosphere, the biosphere, and the oceans. ATM supports such research through the provision of large, complex facilities, community modeling projects, cyberinfrastructure, and individual research grants, providing about 60 percent of the total federal support for academic atmospheric research.

ATM provides support for: 1) basic science projects and 2) the acquisition, maintenance, and operation of observational and cyberinfrastructure facilities and services that enable modern day atmospheric science research activities.

For the science activities supported by ATM, a variety of modes of support are used. Although the majority of this support is through the traditional "individual investigator" merit-reviewed, multi-year grants, ATM also supports small scale, limited-duration exploratory research projects; collaborative or multi-investigator group projects focusing on a particular project, subject, or activity; large center or center-like projects; and funding for the research conducted by NSF's National Center for Atmospheric Research (NCAR), which extends and enhances research at universities.

Facility funding is provided through cooperative agreements to NCAR and several other institutions to acquire, maintain, and operate specific observational and cyberinfrastructure facilities that support the research and educational activities of NSF-sponsored projects, scientists, and students.

ATM supports a diverse portfolio of research, education, and infrastructure activities. Approximately 46 percent of the annual budget of ATM is used to support individuals and small groups of researchers, with approximately 17 percent of the total division budget being available to support new research grants.

ATM priorities for FY 2009:

- Natural Hazards: Building on years of research to understand and predict weather and space weather phenomena, these research activities will be augmented to better understand and predict extreme events such as cyclone formation and life cycle;
- Biogeochemical Cycles: Research in this area includes an emphasis on understanding the sources, sinks, and processes which control the atmospheric abundance and distribution of carbon, water, and other environmentally important elements;
- Environmental Modeling: Support for new data assimilation and innovative mathematical and statistical techniques will improve predictions of fundamental space, atmospheric, and Earth system processes;
- Cyberinfrastructure and Numerical Models: Improvements in this area will allow new discoveries, greater access to atmospheric data, and improved understanding of the atmospheric environment; and
- Interagency and International Programs: ATM will continue support of these programs, including the Climate Change Science Program, the U.S. Weather Research Program, the National Space Weather Program and cooperative international science programs.
- ATM will accelerate investment in NCAR to significantly increase progress towards understanding the Earth system and improve research infrastructure capabilities available to the atmospheric sciences community.

Changes from FY 2008:

- The increase in FY 2009 will permit targeted key areas of research which were flat funded in FY 2008 to move forward. The increased support for research and education grants and centers by $17.58 million, to a total of $116.83 million, will also permit limited growth in the disciplinary programs, viz:
  - an increase of $4.0 million in research on natural hazards (i.e. severe weather and space weather);
  - an increase of $4.0 million for cyberinfrastructure investments; and
  - an increase of $9.58 million in other disciplinary programs.

Limited additional funds in FY 2008 prevented efforts to enhance the ATM-supported facilities. With an FY 2009 increase of $14.30 million to a total of $135.75, ATM will accelerate efforts to provide the community with robust, accessible, and world-class ground, airborne, and space-borne observational facilities and services. This increase includes:

- an increase an increase of $9.05 million for NCAR; and
- an increase of $5.25 million for operations of AMISR and other atmospheric research facilities.

Additional information on major ATM-supported facilities is available in the Facilities chapter.

EARTH SCIENCES $177,730,000

The FY 2009 Request for the Division of Earth Sciences (EAR) is $177.73 million, an increase of $21.65 million, or 13.9 percent, over the FY 2008 Estimate of $156.08 million.

Earth Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Earth Science Project Support	117.66	120.90	139.57	18.67	15.4%
Instrumentation and Facilities	35.17	35.18	38.16	2.98	8.5%
Earth Sciences	**$152.83**	**$156.08**	**$177.73**	**$21.65**	**13.9%**
Major Components:					
Research and Education Grants	99.55	97.68	107.93	10.25	10.5%
Centers Programs					
Sustainability of Semi-Arid Hydrology and Riparian Areas	3.29	2.96	2.96	-	-
National Center for Earth-Surface Dynamics	3.60	3.60	3.60	-	-
Facilities					
Incorporated Research Institutions for Seismology (IRIS)	11.77	11.75	12.20	0.45	3.8%
EarthScope Operations	11.63	17.61	26.29	8.68	49.3%
Other Earth Sciences Infrastructure	23.00	22.48	24.75	2.27	10.1%

Totals may not add due to rounding.

About EAR:

The Earth functions as a complex system that affects every aspect of our daily lives. Earthquakes and related tsunamis periodically result in devastating loss of property and lives, and erupting volcanoes are fed by tectonic processes deep in the earth and may create great societal disruption. The Earth's liquid-core-generated magnetic field is undergoing rapid change that may be related to mantle convection processes. Our energy is largely provided by fossil fuels discovered in the subsurface and pumped or mined. The energy industry pumps liquid carbon dioxide into geological formations both as means of enhancing oil recovery and sequestration of carbon from the fossil fuel-dependent power generation process. The clean water we require to sustain life is made available through the hydrologic cycle. Clues to the climate change process lie in buried sediments and rocks that can be analyzed from drill cores. Soil forming and modification processes directly impact agriculture. EAR supports the study of these and many other Earth processes by providing funds for research and education, instrumentation, cyberinfrastructure, and shared-use facilities.

EAR supports a diverse portfolio of research, education, and infrastructure activities. Approximately 65 percent of the annual budget of EAR is used to support individuals and small groups of researchers, with approximately 31 percent of the total division budget being available to support new research grants.

Earth science is moving into a new era as we deploy an unprecedented array of instrumentation to image the planet's interior, sense the tectonic motions of the surface (for example, with the Global Seismographic Network and NSF's EarthScope project), and establish observatories for study of the Earth's environmental systems. Massive amounts of data generated by these observations require a revolution in hardware and software capability. Geoinformatics is the collaboration between geoscientists and computer scientists to utilize these data and solve complex scientific problems. EAR has enhanced its support to link available data sets, standardize documentation, and provide easy-to-use access tools and computer modeling and analysis codes for scientists and educators alike. Projects currently supported include:

- Consortia of universities, such as the Incorporated Research Institutions for Seismology (IRIS), UNAVCO, Inc. and WInSAR, maintain highly sophisticated seismic, geodetic, and satellite radar data that are heavily used by the research and hazards community. For example, the seismic data provided by the IRIS Global Seismographic Network gave emergency personnel the first indication of the location and severe damage potential of the great Sumatra earthquake and tsunami of December 2004.
- EAR is supporting the development of a hydrologic information system that will provide seamless access to a variety of datasets such as the National Water Information System, the Ameriflux tower network, and the National Climatic Data Center. These systems are increasingly vital for decisions affecting water management in arid regions, flood mitigation, and groundwater pollution containment.
- Geoinformatics-supported projects are linking data sets bearing on sedimentary sequences and geologic time. This will greatly improve our understanding of the Earth's surface environments and climate changes in deep time.
- The Southern California Earthquake Center (SCEC) has been utilizing computational facilities at the University of California San Diego Supercomputer Center to build complex models of the crust of southern California and its response to great earthquakes on local faults. Their results are providing significant input to disaster preparedness and a better understanding of fundamental earthquake processes.
- The Computational Infrastructure for Geodynamics (CIG) project, headquartered at the California Institute of Technology, but with participation of at least 24 other research institutions, will focus on developing advanced software to enable individual Earth scientists to produce more realistic simulations in fields such as seismology, plate tectonics, volcanism, and geomagnetism.

EAR priorities for FY 2009:

- EarthScope Operations and Science Support: The new EarthScope facility will begin full operations and maintenance enabling new science at the intersection of several subfields within the earth sciences. Construction activities will conclude in FY 2008, and full operations begin in FY 2009. Supporting the operation of the facility and the science it enables continues to be a high priority for EAR. Additional information can be found in the Facilities chapter.
- Maintaining a strong, flexible program of research and education grants to create new ideas and technologies and attract and train students is the primary focus in stewardship of the EAR portfolio. Emphasis will be given to increasing the support for theoretical research, including the biological geosciences, the hydrologic sciences and the study of natural hazards, such as earthquakes and volcanic eruptions. The key element across the EAR portfolio is expanding the science community's capability for computationally challenging global-scale research, such as dynamic modeling of Earth system processes, and managing and integrating very large data sets.

Changes from FY 2008:

- In FY 2008, EarthScope operations and maintenance could only be supported at $17.61 million rather than $21.61 million as requested. The FY 2009 Request addresses this shortfall by increasing the level to $26.29 million.
- An increase of $750,000 will be invested in Critical Zone Observatories, coordinated field installations aimed at elucidating the interactions of natural systems in the Earth's near surface environment.
- Research programs across EAR will be augmented by $10.25 million.

INNOVATIVE & COLLABORATIVE EDUCATION AND RESEARCH $56,820,000

The FY 2009 Request for the Division of Innovative & Collaborative Education and Research (ICER) is $56.82 million, level with the FY 2008 Estimate.

Innovative and Collaborative Education and Research Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Innovative & Collaborative Education and Research	**$56.82**	**$56.82**	**$56.82**	**-**	**-**
Major Components:					
Research and Education Grants	51.29	51.22	51.22	-	-
International Collaborations	5.53	5.60	5.60	-	-

About ICER:

ICER supports novel, complex, or partnership projects in both research and education. These investments cut across traditional boundaries within the geosciences, encouraging interdisciplinary activities and responding directly to critical needs of the entire geoscience community. ICER's principal goals are to develop innovative means to initiate and support geoscience education, attract underrepresented groups to careers in the geosciences, foster the interchange of scientific information nationally and internationally, and to join with other parts of NSF in major integrative research and education efforts.

ICER supports a diverse portfolio of research and education activities. Almost 90 percent of the annual budget of ICER is used to support individuals and small groups of researchers, with approximately 44 percent of the total division budget being available to support new research grants.

ICER Priorities for FY 2009:

Education and Broadening Participation in the Geosciences: Cross-divisional education activities include investments in development of curricula and resources specific to broad geoscience education, a leadership activity for geoscience teachers, and support for internet capabilities for geoscience education. In FY 2009, resources will be targeted at increasing the diversity of the geoscience workforce and enhancing the linkages between existing education and diversity projects and LSAMP awards. In a partnership with NASA, NSF will continue support for the GLOBE program. GEO contributes to programs for interdisciplinary graduate education (IGERT) and outreach to students (GK-12).

Interdisciplinary Research: ICER supports a major competition on Carbon and Water in Earth Systems. This research is within the NSF-wide framework for Environmental Research and Education and aims to increase fundamental understanding of the interrelation of physical, chemical, geological, hydrologic, atmospheric, and biological processes that comprise Earth's natural systems. Examples include highly interdisciplinary programs that involve several NSF directorates, such as solicitations on Coupled Natural and Human Systems and Human and Social Dynamics, particularly regarding decision making and uncertainty.

International Collaborations: ICER will continue support of targeted, catalytic international partnerships related to the broad interests of the geosciences, especially those that encourage global and regional scientific observations and information-sharing, and enable participation by U.S. investigators. One example is the Inter-American Institute for Global Change Research, a program that fosters research across the Americas.

Changes from FY 2008:

No changes in programmatic support are requested from the FY 2008 Estimate.

OCEAN SCIENCES $353,540,000

The FY 2009 Request for the Division of Ocean Sciences (OCE) is $353.54 million, an increase of $43.08 million, or 13.9 percent over the FY 2008 Estimate of $310.46 million.

Ocean Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Ocean Section	115.64	115.64	130.70	15.06	13.0%
Integrative Programs Section	112.54	112.54	128.54	16.00	14.2%
Marine Geosciences Section	80.58	82.28	94.30	12.02	14.6%
Ocean Sciences	**$308.76**	**$310.46**	**$353.54**	**$43.08**	**13.9%**
Major Components:					
Research and Education Grants	163.52	175.45	195.20	19.75	11.3%
Long-term Ecological Research Centers	3.64	3.64	3.64	-	-
Centers Program					
Center for Coastal Margin Observation/Prediction	4.00	4.00	4.00	-	-
Facilities					
Academic Research Fleet	87.94	73.16	87.96	14.80	20.2%
Integrated Ocean Drilling Program (IODP)	34.71	39.26	47.74	8.48	21.6%
Other Ocean Sciences Infrastructure	14.95	14.95	15.00	0.05	0.3%

Totals may not add due to rounding.

About OCE:

Research, education, and infrastructure funded by OCE address the central role of the oceans in a changing Earth and as a national strategic resource. OCE supports interdisciplinary research of the water column to better understand controls on natural processes such as: CO_2 exchange between the oceans and atmosphere and implications for ocean acidification; air-sea exchange of heat and consequences for major storms and hurricanes; impact of natural and anthropogenic change on food webs and fishery stocks; and oceans and human health. Geologic studies of the ocean margins and sub-seafloor investigate past ocean and climate conditions; natural hazards associated with earthquakes, volcanic eruptions and tsunamis; cycles of water and CO_2 in the deep Earth; and biological strategies used in the deep biosphere. Ocean education, formal and informal, draws on the interdisciplinary nature of ocean sciences, sophisticated visualization capabilities and the impact of the oceans on environmental change. Ocean science requires access to the sea; OCE supports research vessels, deep submergence capability including submersibles and autonomous vehicles, and technologically advanced sensors and instrumentation

The OCE portfolio has three highly integrative programmatic areas of support:

- Research grants include awards to individual scientists, collaborative groups, and to several large coordinated projects involving international partners and major shared-use facilities.
- Education grants support graduate and undergraduate research experience, K-12 educational activities, and informal education for the general public. The Centers for Ocean Science Education Excellence (COSEE) form a major education and outreach network for OCE.
- OCE supports acquisition, operation, and maintenance of major world-class facilities required to provide access to the oceans in order to address the highest priority science questions.

OCE supports a diverse portfolio of research, education, and infrastructure activities. Approximately 50 percent of the annual budget of OCE is used to support individuals and small groups of researchers, with approximately 35 percent of the total division budget being available to support new research grants.

OCE Priorities for FY 2009:

Enhancement of the existing OCE programs to maintain a strong, flexible portfolio of research and education grants with commensurate facilities support to create new ideas and technology and attract and train students, is a highest priority.

- The Ocean Observatories Initiative (OOI) remains a high priority to provide sustained time-series observations of dynamic and complex processes within the oceans and below the seafloor. Concept and development activities are ongoing, with Final Design Review planned in early FY 2009.
- The Integrated Ocean Drilling Program (IODP), an international partnership of scientists, research institutions, and agencies, uses ocean drilling to explore the evolution and structure of the Earth and its oceans as recorded in the ocean basins. The program will increase by $8.48 million in FY 2009, the first full year in which three drilling platforms will be available, after refit of the U.S. drillship (the SODV).
- OCE will contribute to long-term priorities of the Ocean Research Priorities Plan, including the biological and chemical consequences of ocean acidification, and multi-year interdisciplinary studies of the Southern and Atlantic Oceans, key to quantifying the role of the ocean in climate, through strong international partnerships. OCE also supports research in the four near term priorities: comparative analysis of marine ecosystems; the Atlantic meridional overturning circulation and its role in abrupt change; development of sensors for ecosystem observation; and the effects of persistent forcing and extreme events on coastal environments.
- OCE will continue its partnership with EAR and ATM to support interdisciplinary research in two priority areas: Emerging Trends in Biogeochemical Cycles and PaleoPerspectives in Climate Change
- COSEE will begin to incorporate ocean observations from seafloor HDTV and autonomous underwater vehicles and gliders in anticipation of OOI and to foster interactions among research institutions, formal education organizations, and informal education providers like museums to deliver high-quality education programs that promote a deeper public understanding of the oceans, their influence on quality of life and national prosperity, and their growing need for work-force development.

Changes from FY 2008:

- Research and education grants increase by $18.89 million, to a total of $195.20 million. OCE will continue to support forefront areas of ocean science, with expanded emphasis on complex systems and the temporal exploration of the oceans. Education and outreach activities will receive continued emphasis: enhancing COSEE, expanding diversity within the research community, and integrating research and education, including the training of young ocean scientists.
- Support for research infrastructure increases $23.33 million, to a total of $150.70 million, with increases targeted at the Academic Research Fleet to maintain the number of supported ship days and at the Integrated Ocean Drilling Program. Additional detail for these two programs can be found in the Facilities Chapter.
- Restricted FY 2008 budget growth means that support for the new 3-platform phase of IODP grew only by $2.56 million; the FY 09 request now includes $8.48M to bring IODP to previously planned levels.

MATHEMATICAL AND PHYSICAL SCIENCES $1,402,670,000

The FY 2009 Budget Request for the Mathematical and Physical Sciences (MPS) Directorate is $1.40 billion, an increase of $235.36 million, or 20.2 percent, over the FY 2008 Estimate of $1.17 billion.

Mathematical and Physical Sciences Funding

(Dollars in Millions)

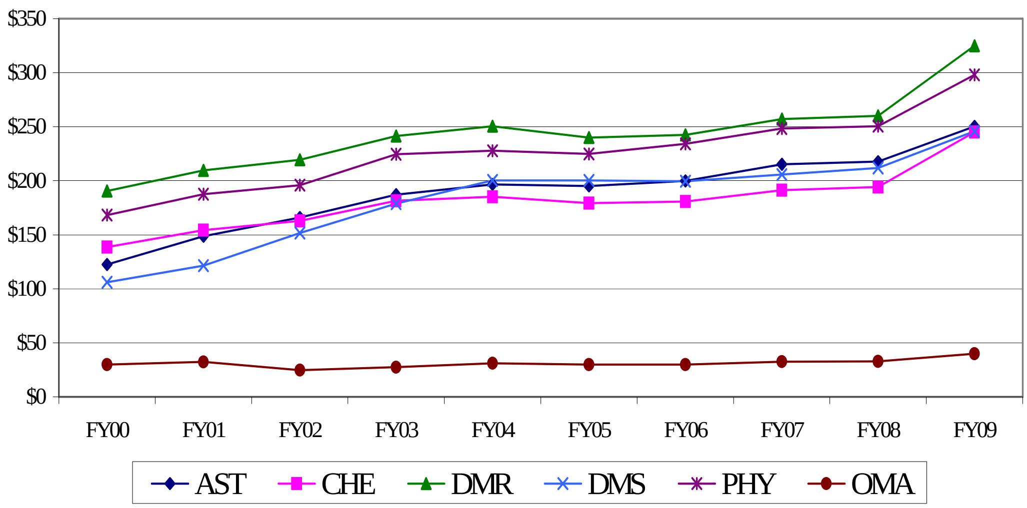
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Astronomical Sciences	$215.39	$217.86	$250.01	$32.15	14.8%
Chemistry	191.22	194.22	244.67	50.45	26.0%
Materials Research	257.27	260.22	324.59	64.37	24.7%
Mathematical Sciences	205.74	211.79	245.70	33.91	16.0%
Physics	248.47	250.52	297.70	47.18	18.8%
Multidisciplinary Activities	32.64	32.70	40.00	7.30	22.3%
Total, MPS	$1,150.73	$1,167.31	$1,402.67	$235.36	20.2%

Totals may not add due to rounding.

The Mathematical and Physical Sciences Directorate (MPS) supports a broad portfolio of investments in fundamental research, facilities, and instruments that enable discovery and development, and through integrated education and research activities that contribute to the development of the science and engineering workforce. The portfolio includes MPS participation in NSF-wide and interagency research and education, and emphasizes discovery, innovation, and learning aligned with the overall goals of the American Competitiveness Initiative (ACI), the America COMPETES Act (ACA), and NSF's mission and vision.

MPS Subactivity Funding

(Dollars in Millions)



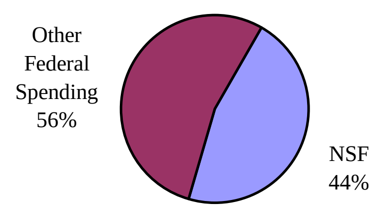
RELEVANCE

Mathematical and physical sciences play a major role in America's overall competitiveness. MPS scientists and mathematicians provide the basic knowledge required for advances in engineering and health-related disciplines, and supply a broad basis for technological innovation in industry, defense, homeland security and national security. They investigate the fundamental properties of matter, determine the complex laws governing chemical reactivity, and develop the mathematical and statistical tools needed to formulate and solve such problems. America's economic strength depends on her ability to generate and harness the latest in scientific and technological developments and to apply these developments to real-world applications. MPS-supported research sparks the innovation crucial to maintaining U.S. competitiveness and generating new industries, focusing on fundamental discoveries to produce valuable and marketable technologies.

MPS-supported research also advances the frontiers of knowledge, excites the imagination, and can lead to new basic concepts. It involves cutting-edge basic research ranging from the structure and evolution of the universe to the fundamental particles and processes of matter; from the behavior and control of molecules at the nanoscale to the complexity of their chemical interactions in materials and life processes; from developing new mathematical structures and theories to transforming them into models of natural systems that connect to computation, experimentation, and observation. It spans the spatial scales from quarks to the cosmos and time scales from the incredibly short to the unimaginably long. It brings the perspective and methodologies of the mathematical and physical sciences to exploring complex biological systems, to human and social dynamics, and to sustainability of energy and the environment.

The development of new ideas and new tools in the mathematical and physical sciences depends strongly on the support provided by the MPS Directorate. MPS provides about 44 percent of federal funding for basic research at academic institutions in the mathematical and physical sciences (with percentages ranging from 34 percent for physics to about 60 percent for mathematical sciences). Much of the Nation's progress at the cutting edge of astronomical sciences, physics, and materials research relies on MPS-supported facilities, including ground-based telescopes, particle accelerators and colliders, and materials laboratories. In addition, MPS collaborates with other disciplines within NSF and partners with other agencies, the private sector, and other nations.

Federal Support of Basic Research in Math and Physical Sciences at Academic Institutions



Both the ACI and ACA place high priority on enhancing the strength of the U.S. technical and instructional workforce. MPS integrates its investments in research and infrastructure with investments aiming to improve the quality and diversity of the U.S. science and engineering workforce and to enhance the public's knowledge of MPS fields by linking both formal and informal education and training programs to forefront research activities in the U.S. and other countries.

A diverse, internationally competitive, and globally-engaged workforce of scientists, engineers, and well-prepared citizens is required for global competitiveness. Through both direct support and its many centers and institutes, MPS continues to make investments in all phases of education – from K-12 through undergraduate, graduate, postgraduate, and continuing education, as well as outreach activities. In FY 2009, MPS will include a concentrated effort, the American Competitiveness Initiative Fellowships, to link undergraduate and graduate education, postdoctoral research, and early faculty experience in areas of particular relevance to ACI and ACA. MPS will continue to emphasize activities connecting undergraduate education with research, taking advantage of the larger numbers and greater diversity in this pool. MPS will also support partnerships aimed at enhanced teacher preparation, broadened graduate and postdoctoral opportunities, and more informed teaching and learning strategies. The MPS strategy uses the excitement of research at the frontier to attract the next generation of scientists and engineers.

In FY 2009, Division allocations reflect the strong emphasis MPS is placing on investments and activities that most directly tie to ACI and ACA.

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, MPS……….......………………..…………………………………….......$1,167.31

Astronomical Sciences Division (AST) +$32.15

Increased funding for research grants and instrumentation, with emphasis on addressing scientific priorities articulated in the National Research Council's "Astronomy and Astrophysics for the New Millennium"; cyberscience and cyberinfrastructure, including implementation of a national virtual observatory in partnership with NASA and the development of tools to handle large data sets; Gemini Observatory operations and instrumentation and continuing ramp-up of operations for the Atacama Large Millimeter Array (ALMA); and strategic public-private partnerships, including design for the Giant Segmented Mirror Telescope.

Chemistry Division (CHE) +$50.45

Increased funding for establishing Centers for Chemical Innovation to address fundamental research grand challenges in chemistry and ACI and ACA goals; create an ACI fellows program to bridge career transitions on the way to becoming science faculty and to promote innovation and diversity in chemistry; support the NSF-wide activity Science and Engineering Beyond Moore's Law[1] as well as Quantum Information processes for future computational paradigms and technology; promote discovery at the interface with the life sciences with special emphasis on "intelligent" adaptive self-assembly and designed emergent properties and functionality; investment in next generation cyber-enabled chemical imaging tools and new collaborations that will lead to transformative approaches to theoretically model complex molecular structures.

Division of Materials Research (DMR) +$64.37

Increased funding for fundamental research addressing nanoscience and engineering and the NSF-wide activity Science and Engineering Beyond Moore's Law that encompasses novel materials and phenomena required for the future development of entirely new computational and communications technologies; quantum information science; the interface between the physical and life sciences including biomaterials and adaptive systems technology. Also, increased support for the materials aspects of computational discovery and innovation; broadening participation in materials research through research and education partnerships; expanded support for Materials Research Science and Engineering Centers; the creation of transformative research groups; support for ACI Fellows; maintaining support for world-class user facilities while enabling the development of future instrumentation; and continuing strong support for international collaborations and partnerships in materials research.

[1] Moore's Law: In 1965 the co-founder of Intel, Gordon E. Moore, predicted that computing power, based on semiconductor integrated circuits, would double every 18 to 24 months, a prediction that has had staying power for over 40 years.

Division of Mathematical Sciences (DMS) +$33.91

In addition to strengthening research in the core disciplines, increased funding for mathematical and statistical sciences supports activities that (1) strengthen the development of underlying concepts and enable effective partnering with other science and engineering disciplines; (2) promote cyber-enabled discovery and innovation through modeling, analysis, algorithms, and simulation that provide new ways of obtaining insight into the nature of complex phenomena; (3) confront the challenges of science and engineering beyond Moore's Law; (4) advance our understanding of algorithms for quantum information science; (5) explore the interface between the mathematical and biological sciences; (6) investigate the mathematical structure of adaptive systems technology; (7) create ACI fellows to provide more undergraduates with interdisciplinary, discovery-based research experiences; and (8) support more early career researchers in the mathematical sciences.

Physics (PHY) +$47.18

Increased funding to advance the frontiers of physics, with emphasis on atomic, molecular, and optical physics, especially science beyond Moore's Law; physics at the information frontier, especially quantum information science, cyberinfrastructure and cyber-enabled discovery; the physics of living systems; and the interagency Physics of the Universe activities with the Division of Astronomical Sciences, Department of Energy, and NASA; expanded resources for the design and development of next-generation instrumentation and facilities, especially the Deep Underground Science and Engineering Laboratory (DUSEL); and education and outreach activities, including broadening participation in the research community and a mid-career ACI Fellows program. Support for operations for IceCube and the National Superconducting Cyclotron Lab (NSCL) will be enhanced, while funding for the Cornell Electron Storage Ring (CESR) will be reduced as part of the phase-out plan.

Office of Multidisciplinary Activities (OMA) +$ 7.30

Increased funding for collaborative activities aimed at initiating innovative cross-disciplinary research and connecting fundamental ideas to innovative technologies, as well as broadening participation in and informing the public about MPS disciplines.

Subtotal, Changes +$235.36

FY 2009 Request, MPS…………………….……………………………………………………….$1,402.67

Summary of Major Changes in Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, MPS.......……………......……………………………………….……......$1,167.31

<u>Discovery</u> +$185.68

Cyber-enabled Discovery and Innovation (CDI) (+$8.65 million).

Modeling, algorithms, software, and simulation are essential research components in all MPS disciplines, as are virtual computing networks accessing common databases and analytic tools. Examples include the synthesis and characterization of new molecular systems; the prediction and discovery of new materials and new states of matter; the creation, manipulation, and control of quantum mechanical states in solid and condensed states of matter; the development of mathematical structures to describe complex, multi-scale networks as typified by electrical power grids and the internet; and the creation of visualization and "mining" techniques for both sparse and dense data. MPS will continue its collaborations with other directorates in NSF's high priority activities in CDI, creating synergy with related activities in Cyberinfrastructure and enhancing the government-wide Networking and Information Technology Research and Development effort.

Science and Engineering Beyond Moore's Law (+7.0 million)

MPS will lead the Foundation in Science and Engineering Beyond Moore's Law (SEBML), a multidisciplinary research investment with strong ties to economic competitiveness and potential for transformation. Tied to both nanotechnology and cyberinfrastructure, it builds on past NSF investments in these areas and energizes them with new directions and challenges. Activities in this area include research into new materials, devices, and processes that exploit the capability to create and manipulate specific quantum states and new algorithms that exploit hardware and architecture characteristics to deliver maximal total computing power, including those that exploit quantum interactions. MPS will work with the other Directorates in areas such as developing new connection architectures with new control principles, massive parallelism, and designed asynchronicity and indeterminacy and creating new software that allows the effective use of new devices.

Adaptive Systems Technology (+$3.49 million).

MPS will join partners across NSF in support of exploration of questions in Adaptive Systems Technology, such as how a signal from the external world can be represented in the brain, and mechanistic models to describe processes that involve signaling at every level from individual molecules to cells to circuits to systems. Activities will include building models and improving their analyses to enable the prediction of experiments and improve their theoretical underpinnings; understanding the behavior of physical and biological systems, often far from equilibrium, across a wide range of length and time scales; developing new instrumentation that enables new types of exploration; and creating synthetic biological systems that can mimic nature. Emphasis will be placed on information dynamics and networks; multi-scale phenomena and nonequilibrium systems; design of functional systems and devices inspired by brain sciences; and new instrumentation development for study of the brain. Activities in this area show great promise for innovation in an information and knowledge-based society. The research in this area will support the Administration's emphasis on Understanding Complex Biological Systems.

Disciplinary and Interdisciplinary Research (+$140.46 million).

MPS assigns high priority to providing strong support of individual investigators and small groups pursuing fundamental research across all MPS disciplines. Support for the core discovery mission (apart from the special investments immediately above) is paramount to meeting science opportunities in MPS disciplines, to maintaining a competitive workforce in these areas, and to enabling a vital interdisciplinary effort. Extraordinary research opportunities exist in all of the MPS sciences, as well as opportunities to connect with ACI, Administration, and NSF priorities. Within the context of disciplinary and interdisciplinary research, MPS emphasis areas interact with each other, with NSF and Administration priorities, and with the overall portfolio in synergistic fashion, reflecting commonalities in the underlying complex physical systems. In FY 2009, MPS will continue its research in areas such as Science and Engineering Beyond Moore's Law, Physical Sciences at the Nanoscale, Physics of the Universe, Mathematical Sciences, Complex Biological Systems, and Sustainability. Specific emphases for FY 2009 include:

- *MPS Life Science Interface (+$6.0 million).* Lessons from the biological world inform new directions for fundamental physical sciences discovery, solutions for important technological problems facing society, and synergistic advances in the life sciences. MPS has already made a strong investment in research that is at this interface of the mathematical and physical sciences and biology. For FY 2009 MPS will strongly support the Administration's focus on Understanding Complex Biological Systems by increasing funding for this research, developing a cohesive program across MPS and with the Directorate for Biological Sciences. The potential for meeting ACI objectives is extremely high as well, as the MPS emphasis on materials, processes, and devices creates the opportunity for fundamental research that translates quickly into marketable technology in areas such as pharmaceuticals, medical imaging, and various types of implants.

- *Quantum Information Sciences (QIS) (+$5.0 million).* The country that first achieves a viable technology in quantum information sciences will have both a considerable competitive and a strong national security advantage. If another nation should achieve such technology earlier than the U.S., potential exists for significant disruption to our national security. It is therefore important to draw the focus of the academic community into these critical areas. Specifically, MPS will concentrate on quantum computing and quantum communication using entangled states, novel theoretical and experimental research in the condensed matter sciences, and advanced understanding and implementation of algorithms for quantum information sciences.

- *ACI Fellows Program (+$4.0 million).* ACI and ACA call for increased training opportunities and support for young investigators. In FY 2009, MPS will include a concentrated effort to meet this goal, following on the small FY 2008 pilot program in this area. Our ACI Fellows program gives each Division the flexibility to emphasize a different part of this goal. Some of the programs will grant Fellowships intended to link undergraduate and graduate education, postdoctoral research, and early faculty experience in areas of particular relevance to national competitiveness. Others will emphasize broadening participation or increasing industrial experience at all academic levels. A crucial element of all Fellowships will be the connection between fundamental research and innovation. The program will also serve to encourage best practices in departmental culture.

- *Human and Social Dynamics (-$500,000).* The Human and Social Dynamics priority area ends in FY 2008 with activities absorbed into other ongoing programs.

CAREER (+$5.70 million).

The CAREER program remains the primary mechanism for jump-starting junior faculty toward independent careers in research and education, a key element of ACI. The increased funding in FY 2009 will fund at least ten to twelve additional CAREER grants.

Centers (+$20.38 million).

MPS will continue to put emphasis on its Centers program. Centers allow researchers to pursue the goals of the ACI through collaboration towards innovation in the MPS sciences.

- *Centers for Chemical Innovation (+$12.5 million).* The CCI Program was initiated as a pilot in 2004 (under the name *Chemical Bonding Centers*) with several ambitious goals: to support high risk, transformative science; to energize the chemistry research community to tackle grand challenges; and to creatively engage the public. The name change to *Centers for*

Chemical Innovation reflects the addition of innovation as a key feature of the scientific outcomes expected from these centers. The CCI Program awards funds in two phases: Phase I is a three-year grant to explore potentially transformative ideas and initiate partnerships, and Phase II is a five-year grant awarded to extremely promising Centers following competition at the end of their Phase I award. The increase in FY 2009 will allow MPS to start three new Phase I Centers in FY 2009 as well as initiate and expand funding for Centers successful in the FY 2008 Phase II competition.

- *Materials Research Science and Engineering Centers (+$8.0 million).* MRSECs address fundamental problems in materials and condensed matter science of scope and complexity requiring the advantages of scale and interdisciplinary interactions. These centers focus on interdisciplinary research at the interface between materials and biology, computational materials, quantum information science, and nanoscale materials. As underscored by a recent study of MRSECs by the National Academy of Sciences (NAS), the MRSECs support cutting edge, transformative science and engineering of the highest quality, emphasize workforce development through the integration of research, education, and diversity, and stimulate economic activity through active collaborations with industry, national laboratories, and international partners. Based on recommendations by the NAS study, plans are to increase the average center award size, to enhance the support for infrastructure, and to enhance the effectiveness of the national network of MRSECs. The increased funding will allow the full support of 2 - 3 new centers that were initiated with partial start up support as a result of the 2008 MRSEC competition. Emphasis for the new centers will be to continue the MRSEC trademark of high risk, transformative research. In addition, these funds will allow continued support for the newly established MRSEC based instrumentation and facility network. The network will allow cyber-enabled connections and service to non-MRSECs, including smaller institutions.

- *Nanoscale Science and Engineering Centers (+1.0 million).* NSECs support synergistic science and engineering research and education in emerging areas of nanoscale science and technology. This cross-Foundation program addresses a broad spectrum of research topics. NSF currently supports 17 NSECs. DMR co-funds 12 NSECs and has lead responsibility for three. Increased funding will allow additional co-funding for the new NSEC on the Environmental Implications of Nanotechnology (CEIN) and supplementary support for other NSECs at the interface between the physical and biological sciences.

- *Center for Research at the Interface of the Mathematical and Biological Sciences (+$200,000).* In collaboration with the Directorate for Biological Sciences, which will provide the majority of support at $1.80 million in FY 2009, MPS will contribute to this center to stimulate research and education at the interface of the mathematical and biological sciences.

- *Science and Technology Centers (-$1.32 million).* In FY 2009, MPS will phase out funding for its sunsetting STCs. This reduction will affect both the Center for Adaptive Optics in the Division of Astronomical Sciences and the Center for Environmentally Benign Processing in the Division of Chemistry.

Learning +$4.39

Creating a strong environment for learning is a centerpiece of the ACI investment. MPS will continue its focus on existing programs that reach different career levels, from undergraduates through early faculty positions. Discovery-based experiences for undergraduates will continue to be a major priority for MPS. Emphases include broadening participation through increased funding for awards that promote inclusion of women and underrepresented minorities either as principal investigators, students, or postdocs. Specific emphases for FY 2009 include:

- *Research Experience for Undergraduates (REU) (+$1.41 million).* Expansion of REU programs will focus on international research experiences to help develop a workforce that is both globally aware and competitive. A portion of the additional funding requested in FY 2009 will go directly for international REU sites in chemistry.

- *Mathematical Science Post-Doctoral Research Fellowships (MSPRF) (+$1.0 million).* The MSPRF program supports future leaders in the mathematical sciences by providing them with flexibility in the choice of and enabling them to participate in research environments that will have a maximal impact on their future scientific development. The increase in FY 2009 will be primarily used to raise the stipends for these postdoctoral fellowships to a more competitive level.

- *Undergraduate Research Collaboratives (+$840,000).* Underrepresented minorities often leave science before being impacted by the traditional undergraduate research opportunities (including REU programs) that tend to focus on students who have already committed to STEM majors. Undergraduate research at the earliest stages encourages expanded participation by these minorities. Additional models of support are needed that will engage large numbers of first and second year students at both two and four year colleges and that will eventually reach down to middle and high school teachers and students. This program is being piloted by the Division of Chemistry (CHE). Increases in FY 2009 will provide ongoing support for FY 2008 awards as well as new awards in FY 2009.

- *Other (+$1.14 million).* Increases totaling $1.14 million support the Research Experiences for Teachers program, Chemistry's Discovery Corps Fellowships, the Astronomy and Astrophysics Postdoctoral Fellowships, and Integrative Graduate Education and Research Traineeship (IGERT). MPS will provide a total of $8.88 million in FY 2009 for IGERT.

Research Infrastructure +$41.01

Investment in 'tools of science' – facilities and instruments that enable discovery and development – supports not only the science of the MPS disciplines, but also the explicit goals of ACI. MPS will increase support for new and emerging facilities and for instrumentation development, including design and development of future facilities, cyberinfrastructure, and mid-scale projects while downscaling facilities deemed to be of lower priority.

Division of Astronomical Sciences (+$13.25 million).

The increase in the research infrastructure investment for the Division of Astronomical Sciences (AST) is in line with the recommendations of the AST Senior Review.

- *Gemini (+2.0 million).* Increased funding will allow further development of next generation instrumentation, including construction of the Gemini Planet Imager, a camera designed to directly detect planets around nearby stars, and design studies for a wide field optical spectrometer that will collect data from thousands of objects simultaneously.

- *National Astronomy and Ionosphere Center (NAIC) (-$850,000).* Following the recommendation of the Senior Review, funding decreases to achieve a lower base operational level by FY 2010, by emphasizing survey work, modifying the operating mode, and limiting the observing time for astronomical observations.

- *National Optical Astronomy Observatory (NOAO) and National Solar Observatory (NSO) (+$3.28 million).* This increase, keeping pace with inflation, will support the second year of the facilities' response to Senior Review recommendations, which included modest reinvestment in infrastructure and reductions in lower priority programs. Emphasis continues at NOAO on public-private partnerships and development of the national system of astronomical resources through support of the Telescope System Instrumentation Program and other community programs.

- *National Radio Astronomy Observatory (NRAO) and the Atacama Large Millimeter Array (ALMA) (+$8.82 million).* Funding for the Atacama Large Millimeter Array continues to ramp up to enable operations and maintenance of a growing array of antennas and preparation for early science support.

Division of Materials Research (+$12.0 million).

- *National High Magnetic Field Laboratory (NHMFL) (+$5.0 million).* Increased funding will strengthen user support programs and in-house research, education, and training at all levels, including broadening participation, and to meet increased electricity costs.

- *Other MPS Facilities (+7.0 million).* The requested funds will support the technical research and development necessary for the next generation of light source facilities.

Division of Physics (-$3.56 million).

- *Cornell Electron Storage Ring (CESR) (-$5.21 million).* The reduction is targeted toward the close-out of the particle physics program based upon the CESR accelerator. Physicists at Cornell, building upon their technical and analytical expertise, are ramping up their participation in the research programs at the CERN Large Hadron Collider (LHC).

- *IceCube (+$650,000).* MPS shares maintenance and operations for IceCube with the Office of Polar Programs. Operations funding is ramping up toward the steady state as initial research activities are underway.

- *Laser Interferometer Gravitational Wave Observatory (LIGO) (-$1.0 million).* LIGO concluded its mission-defining scientific run (S5), in which a year's data was taken with all three interferometers operating in coincidence, in October 2007. LIGO's operations and maintenance projections and requests for FYs 2008 through 2012 are smaller than the spending for FY 2007, since some employees and resources will be diverted to the Advanced LIGO MREFC project, appropriated as a new start in the FY 2008 omnibus legislation. LIGO operations will, however, continue to analyze data taken during the current and earlier runs and will plan for and conduct future runs until the scheduled shutdown of the detectors in FYs 2010-2011. Science runs planned to begin in 2009 will test technologies that will become part of Advanced LIGO; the detector sensitivity will be at least twice that during the current S5 run.

- *National Superconducting Cyclotron Laboratory (NSCL, MSU Cyclotron) (+$2.0 million).* FY 2009 support will enable near-optimal operations and research at this unique radioactive ion beam facility; this funding level is consistent with recommendations from an external 2006 science and operations review committee.

Division of Mathematical Sciences (-$670,000).

- *National Center for Atmospheric Research (NCAR) (-$670,000).* This decrease is due to the expiration of earlier commitments to this Federal Funded Research and Development Center.

MPS-wide (+$19.99 million)

- *Research Resources* (+$19.99 million). MPS will make a focused investment across the directorate in FY 2009 for Research Resources, especially for mid-scale instrumentation ($7.35 million). Included in the increase for Research Resources is a one-time special allocation of $2.0 million to the Division of Astronomical Sciences for their implementation of Senior Review's recommendations, such as reinvestment in optical and infrared instrumentation for NOAO, and $2.3 million for a general boost to the core AST instrumentation program. An additional $2.34 million is requested for CHE for new investments in cyber-enabled chemistry, multi-user facilities, and instrument development for chemical imaging. DMR will use $4.0 million to support Instrumentation for Materials Research and an additional $500,000 will be used to conduct research underpinning the development of future user facilities.

<u>Stewardship</u> +$4.28

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$235.36

FY 2009 Request, MPS…….……………………………………………………………….$1,402.67

MPS Centers Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Centers for Analysis and Synthesis	-	-	$0.20	$0.20	N/A
Centers for Chemical Innovation	3.00	7.50	20.00	12.50	166.7%
Materials Centers	55.97	54.73	62.73	8.00	14.6%
Nanoscale Science and Engineering Centers	12.48	12.96	13.96	1.00	7.7%
Science and Technology Centers	20.02	18.60	17.28	-1.32	-7.1%
Total, MPS	**$91.47**	**$93.79**	**$114.17**	**$20.38**	**21.7%**

Totals may not add due to rounding.

MPS Facilities Funding
(Dollars in Millions)

Facilities	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Cornell Electron Storage Ring (CESR)	$14.71	$13.71	$8.50	-$5.21	-38.0%
GEMINI Observatory	20.00	20.00	22.00	2.00	10.0%
IceCube	0.25	1.50	2.15	0.65	43.3%
Large Hadron Collider (LHC)	18.00	18.00	18.00	-	-
Laser Interferometer Gravit. Wave Obs. (LIGO)	33.00	29.50	28.50	-1.00	-3.4%
NSCL (MSU Cyclotron)	18.50	18.50	20.50	2.00	10.8%
Nanofabrication (NNUN/NNIN)	2.86	2.80	2.80	-	-
Nat'l High Magnetic Field Laboratory (NHMFL)	26.55	26.50	31.50	5.00	18.9%
Nat'l Astronomy and Ionosphere Center (NAIC)	10.46	10.45	9.60	-0.85	-8.1%
Nat'l Center for Atmospheric Research (NCAR)	-	1.12	0.45	-0.67	-59.8%
Nat'l Optical Astronomy Observatories (NOAO) [1]	39.28	38.55	41.83	3.28	8.5%
Nat'l Radio Astronomy Observatory (NRAO)	47.04	44.52	49.79	5.27	11.8%
Atacama Large Millimeter Array (ALMA)	3.70	8.22	11.77	3.55	43.2%
Other MPS Facilities	12.57	12.47	19.47	7.00	56.1%
Total, MPS	**$246.92**	**$245.84**	**$266.86**	**$21.02**	**8.6%**

Totals may not add due to rounding.

[1]The NOAO total for FY 2009 includes funding for the Telescope System Instrumentation Program at $5.0 million, level with the FY 2008 Request.

NSF-WIDE INVESTMENTS

In FY 2009, the Directorate for Mathematical and Physical Sciences will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

MPS NSF-wide Investments
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Adaptive Systems Technology	-	-	$3.49	$3.49	N/A
Biocomplexity in the Environment	1.00	-	-	-	N/A
Climate Change Science Program	6.81	5.45	6.00	0.55	10.1%
Cyber-enabled Discovery and Innovation	8.78	10.40	19.05	8.65	83.2%
Cyberinfrastructure	61.21	64.56	71.06	6.50	10.1%
Human and Social Dynamics	0.50	0.50	-	-0.50	-100.0%
Mathematical Sciences	67.56	-	-	-	N/A
National Nanotechnology Initiative	169.48	169.48	178.07	8.59	5.1%
Networking and Information Technology R&D	73.70	70.89	73.72	2.83	4.0%
Science and Engineering Beyond Moore's Law	-	3.00	10.00	7.00	233.3%

Adaptive Systems Technology (AST): MPS emphasis in Adaptive Systems Technology will be placed on information dynamics and networks; multi-scale phenomena and nonequilibrium systems; design of functional systems and devices inspired by brain sciences; and development of new instrumentation for study of the brain. MPS divisions will contribute the general principles of the neural organization and communications pathways and explain how the system computes.

Biocomplexity in the Environment, Human and Social Dynamics, and **Mathematical Sciences:** With the conclusion of these priority areas in FY 2007 or FY 2008 (as noted in the table above), key components of these investments will be retained for core programs.

Climate Change Science Program (CCSP): Within MPS, investment in this area is led by the Division of Chemistry through the U.S. Global Change Research Program. The focus is on sustainability, including green chemistry, water chemistry, and energy. A small increase of $550,000 is planned for FY 2009.

Cyber-enabled Discovery and Innovation (CDI): MPS will increase its focus on CDI research by investing $19.05 million in FY 2009, an increase of $8.65 million over the FY 2008 Estimate. MPS divisions will support research on the synthesis and characterization of new molecular systems; the prediction and discovery of new materials and new states of matter; the creation, manipulation, and control of quantum mechanical states in solid and condensed states of matter; the development of mathematical structures to describe complex, multi-scale networks as typified by electrical power grids and the Internet; and the creation of visualization techniques for both sparse and dense data. MPS will continue its collaborations with other directorates in NSF's high priority activities in the CDI investment as well as increase funding within the MPS divisions.

Cyberinfrastructure (CI): NSF's CI activities are related to NITRD investments. All MPS divisions emphasize ways in which cyberinfrastructure – high-end computing, networking, and data collection and management – can enable the science they conduct. The developing capabilities create new opportunities for collaboration in science. Modeling, simulation, and visualization are increasingly important tools for MPS fields, particularly for work that crosses scales of time and space. A total of $71.06 million, $6.50 million over the FY 2008 Estimate, will support investments such as the NSF program in Petascale Simulations and Analysis (PetaApps) for improving hardware, software, and data management capabilities that enable researchers to ask new kinds of questions, which, in turn, stimulate the need for new, more powerful capabilities in cyberinfrastructure. In addition, MPS divisions contribute to research for the next generation of cyberinfrastructure through the development of software and algorithms and through research on next-generation materials for computation and computing.

National Nanotechnology Initiative (NNI): MPS plays an important role, both within NSF and in the interagency working environment in NNI, investing a total of $178.07 million at FY 2009 Request, an increase of $8.59 million over the FY 2008 Estimate. Key areas include fundamental nanoscale phenomena and processes and nanomaterials, with significant investments in instrumentation research, major research facilities, societal dimensions, and education. MPS will also increase its funding for the Environmental, Health, and Safety sub-component area by $2.72 million in FY 2009, consistent with the NSF and Administration focus on this important research. Many of the activities are carried out through interdisciplinary research teams. The Division of Materials Research is the lead division, with significant participation from the Divisions of Chemistry, Physics, and Mathematical Sciences.

Networking and Information Technology Research and Development (NITRD): All MPS divisions participate in funding for the NITRD program. The investment continues to focus in high-end computing infrastructure and applications, with contributions in high-end computing R&D as well as human-computer interaction and information management. Computing in high energy physics and the development of a national virtual astronomical observatory are high-profile examples of MPS investments. In FY 2009, MPS will invest $73.72 million, or $2.83 million over the FY 2008 Estimate.

Science and Engineering Beyond Moore's Law (SEBML): MPS is the lead directorate for Science and Engineering Beyond Moore's Law, partnering with CISE and ENG to promote research into next generation computing power. SEBML research will focus on developing new materials, devices, and processes; new connection architectures; new algorithms; and new software. MPS will invest $10.0 million in FY 2009 for SEBML, an increase of $7.0 million over the FY 2008 Estimate.

QUALITY

MPS maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. The percent of research funds allocated to projects that undergo external merit review was 89 percent in FY 2007, the last year for which complete data exist.

To ensure the highest quality in processing and recommending proposals for awards, MPS convenes Committees of Visitors (COVs), composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. MPS will convene COVs in FY 2008 for the Division of Mathematical Sciences, the Division of Astronomy, and the Office of Multidisciplinary Activities; a COV for the Division of Physics is scheduled for FY 2009.

MPS also receives advice from the Mathematical and Physical Sciences Advisory Committee (MPSAC) on such issues as: mission, programs, and goals that can best serve the scientific community; how MPS can promote quality graduate and undergraduate education in the mathematical and physical sciences; and priority investments in MPS-supported research. The MPSAC meets twice a year. Members represent a cross-section of the mathematical and physical sciences with representatives from many different sub-disciplines within the field and include members from institutions and industry. The committee includes a balanced representation of women, underrepresented minority groups, and geographic regions. MPS also participates in three advisory committees that advise multiple agencies: the High Energy Physics Advisory Panel (with DOE), the Nuclear Science Advisory Committee (with DOE), and the Astronomy and Astrophysics Advisory Committee (with DOE and NASA). Standing committees and studies of the National Research Council provide another mechanism for obtaining advice.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Mathematical and Physical Sciences
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Discovery	$777.46	$799.23	$984.91	$185.68	23.2%
Learning	71.42	63.68	68.07	4.39	6.9%
Research Infrastructure	291.55	293.05	334.06	41.01	14.0%
Stewardship	10.30	11.35	15.63	4.28	37.7%
Total, MPS	$1,150.73	$1,167.31	$1,402.67	$235.36	20.2%

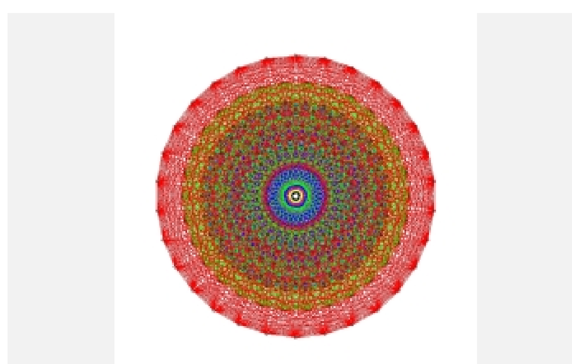
Totals may not add due to rounding.

Recent Research Highlights

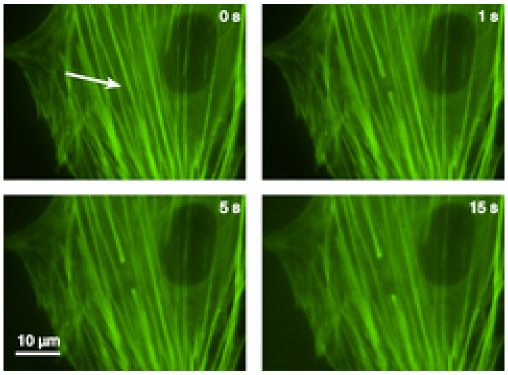
► **New Tricks with Light**: Researchers at Harvard University have stopped a light pulse in one location and made it reappear in another location a little while later. The researchers stopped a kilometer-long light pulse in a small ball of gas with a diameter about the width of a human hair called a Bose-Einstein condensate. An identical kilometer-long light pulse was subsequently made to appear from a second distinct Bose-Einstein condensate. The information about the shape and color of the light pulse was encoded into the quantum mechanical behavior of the atoms and pushed between the two condensates as a traveling matter wave moving at less than one mile per hour. This achievement demonstrates a possible intermediate step in quantum information processing. (PHY)

In a recent experiment at Harvard, light was absorbed and stored in one gas cloud, transferred to another gas cloud by transmission of a matter wave, and then recreated from the second gas cloud. *Credit: Jay Penni Photography.*

► **A Mathematical Solution for Another Dimension**: Ever since 1887, when Norwegian mathematician Sophus Lie discovered the mathematical group called E8, researchers have been trying to understand the extraordinarily complex object described by a numerical matrix of more than 400,000 rows and columns. Now, with support from NSF and the American Institute of Mathematics, an international team of experts consisting of about 20 researchers from the United States and Europe (including the University of Maryland, Cornell University, University of Michigan, University of Utah, Massachusetts Institute of Technology, University of Poitiers and University of Lyon in France) using powerful computers and programming techniques has mapped E8 – a feat numerically akin to the mapping of the human genome – allowing for breakthroughs in a wide range of problems in geometry, number theory, and the physics of string theory. (DMS)



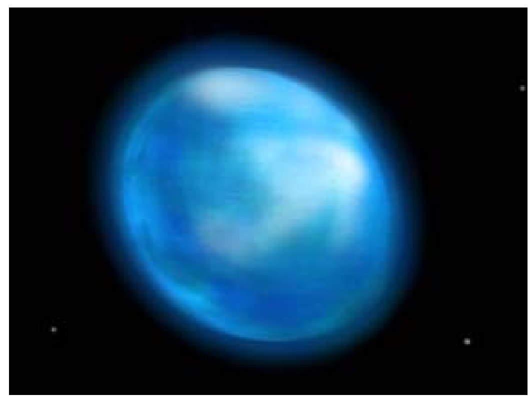
The E8 root system consists of 240 vectors in an 8-dimensional space. *Credit: American Institute of Mathematics.*



Time series of images taken with an optical microscope showing ends of the cut actin filament pulling apart. *Credit: David Weitz.*

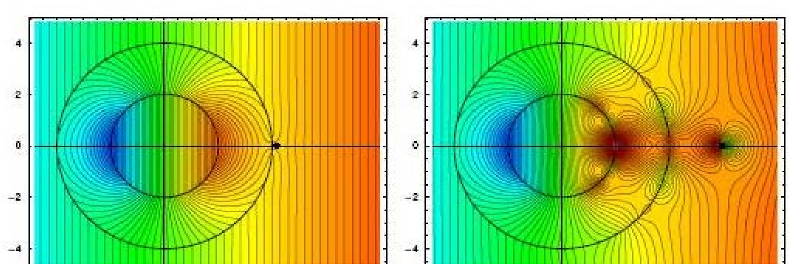
► **Nanosurgery in a Live Cell Using Laser Pulses**: Researchers at the NSF-supported Materials Research Science and Engineering Center at Harvard University performed 'nanosurgery' on a living cell using a pulsed laser to snip a single actin filament. Actin filaments are fibrous strands within a cell that give it structure. When a single filament is cut, it retracts like a broken violin string if the filaments are under tension and being pulled apart. Nanosurgery in a live cell using laser pulses provides critical insight into the behavior of the cytoskeletal network that, in turn, plays a key role in determining the mechanical properties of the cell. (DMR)

► **First Image of a Star Like Our Sun**: Using a suite of four telescopes, an international team of astronomers from St. Andrews University, Cambridge University, Georgia State University, California Institute of Technology, Cornell University, the Laboratoire d'Astrophysique de Grenoble in France, the Michelson Science Center, and the National Science Foundation's National Optical Astronomy Observatory have captured an image of Altair, one of the closest stars to our own and a fixture in the summer sky. This is the first time anyone has seen the surface of a relatively tiny hydrogen-burning star like our own sun. The astronomers captured the image using four of the six telescopes at a facility on Mt. Wilson, California, that is supported in part by NSF. The galaxy is shaped by the effects of relatively rare but powerful, hot, rapidly rotating stars. These stars have more in common with Altair than our own sun; understanding Altair will allow us to better understand how these influential stars scattered throughout the galaxy operate. (AST)



An artist's rendition of Altair, a star that spins so quickly it stretches at its equator. *Credit: Zina Deretsky, NSF.*

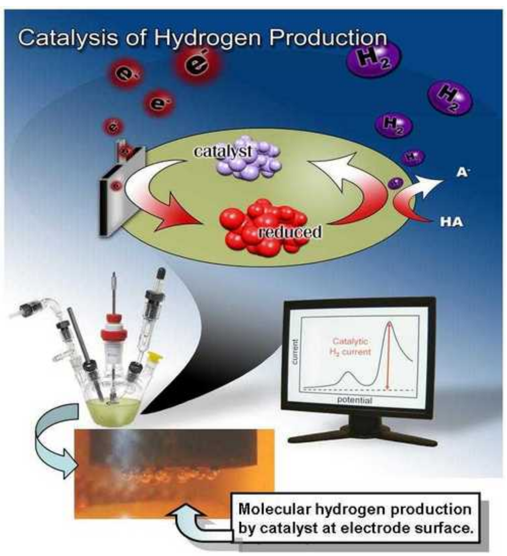
► **The Invisibility Cloak**: Making an object invisible with a cloaking device is commonly regarded as science fiction. Mathematical analysis by NSF-funded researchers at the University of Utah and the University of Technology in Sydney, Australia, however, recently revealed that certain objects are essentially invisible when placed sufficiently close to a superlens. A superlens is a thin transparent film with a negative refractive index that has the ability to resolve scales finer than the wavelength of the incident light. Cloaking occurs when some of the scattered light incident on the object gets trapped at the front surface of the superlens, builds up in intensity via a phenomenon known as anomalous local resonance, and almost exactly cancels the incident light. It's as if the object isn't there. (DMS)



Cloaking action of the cylindrical lens. The figure on the right shows the object in the form of a black dot situated away from the cylindrical lens and significantly disturbing the incident field. The figure on the left shows the object located close to the lens, with the lens and the object essentially invisible to the incident field. *Credit: Professor Graeme Milton.*

One of these pictures contains a hidden map of downtown Washington. Can you tell which one? Newly created analysis software does so with ease. *Credit: Charles Boncelet, University of Delaware.*

► **The Hidden Depths of Pictures**: Steganalysis is the search for hidden messages and is essential because criminals and terrorists may use hidden messages to communicate. Steganography is the process of hiding communications in otherwise innocuous objects, such as digital images. An NSF-supported investigator at the University of Delaware has invented a new method of steganalysis for image-based steganography. The researcher invented a high-performance lossless image compression method that is used to model images and to detect anomalies typical of hidden messages. A test on 1,200 images using two different steganography techniques demonstrated the power of the new method. For the most common technique, steganalysis reached 97 percent accuracy even when only 20 percent of the pixels contained hidden data. For a more concealed embedding, the method was still more than 91 percent correct with 30 percent steganography. (AST)



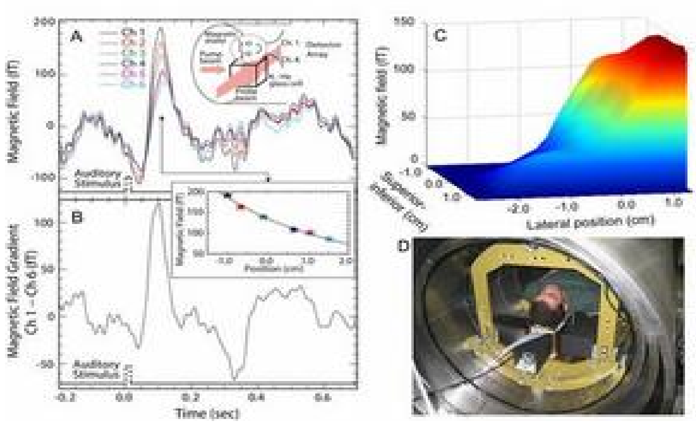
The rate of hydrogen production by these new catalysts is fast. As soon as the acetic acid diffuses to the electrode surface the catalyst converts it to hydrogen and bubbles can be seen at the electrode. *Credit: Suzy Hunter, Greg A.N. Felton, Richard S. Glass, Dennis H. Evans, and Dennis L. Lichtenberger.*

► **Finding Efficient Catalysts for Generating Hydrogen as an Alternative Fuel**: A major challenge in using hydrogen as an alternative fuel is the development of a cheap, efficient, readily available catalyst for chemically combining two electrons and two protons to form molecular hydrogen. Catalysts are substances that are added to chemical reactions to lower the amount of energy needed to make the reaction start and carry on spontaneously. Catalysts for hydrogen production typically lower this energy barrier more than is actually required for the reaction to occur. This over-potential, as it is called, wastes energy and diminishes the value of the catalysts. An NSF-supported team at the University of Arizona has synthesized a new class of compounds that can catalytically produce hydrogen from acetic acid (a component of vinegar) with very small over-potentials. The research can lead to more efficient hydrogen production and to new technologies needed for sustainable energy supplies. (CHE)

► **Determining the Highest Energies in the Universe**: In western Argentina, on the vast plain known as the Pampa Amarilla, or yellow prairie, a new window on the universe is taking shape. The international Pierre Auger Cosmic Ray Observatory looks at the universe's highest energy particles which shower down on Earth in the form of cosmic rays. While the origin of cosmic rays of low-to-moderate energies is believed to originate in supernova explosions within our galaxy, recent observations made by the Auger Observatory indicate that extremely high-energy cosmic rays may have come from galaxies within a radius of a few hundred million light years from our galaxy. The galaxies from which these high-energy cosmic rays are believed to originate show much higher than normal activity at their centers and, when viewed at radio and x-ray frequencies, exhibit pairs of jets of highly energetic material. By detecting and studying these rare very high energy particles, the Auger Observatory is tackling the enigmas of their origin and existence. (PHY)

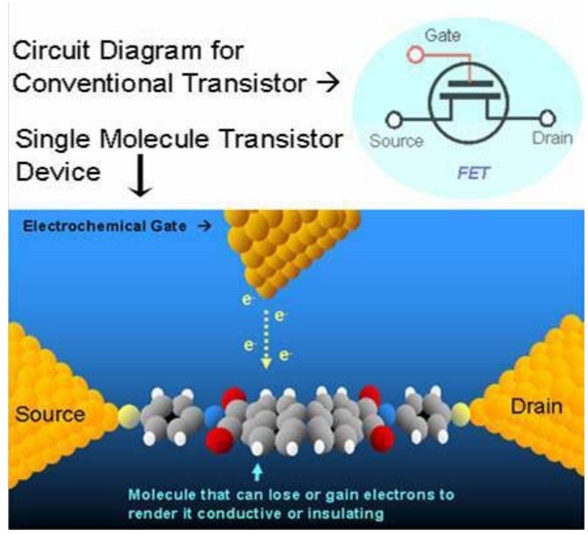
The Los Leones Fluorescence Detector together with its closest Surface Detector tank. *Credit: Pierre Auger Observatory*.

► **Magnetic Brain Imaging**: A modern technique for functional brain imaging, called magnetoencephalography, relies on detecting magnetic fields generated by the brain. Superconducting magnetometers that operate in liquid helium have remained the only detectors with sufficient sensitivity for magnetoencephalography for more than 30 years. A new optical method devised by NSF-funded researchers at Princeton University does not require the complications of cooling with liquid helium and allows the use of much smaller magnetic shields. The technology has the potential to be simpler, less expensive, and more comfortable for the subject. Optical magnetic field mapping also allows much greater flexibility in detector placement compared with cryogenic sensors while using common elements for most components of the system. (PHY)



Magnetic fields recorded with a light detector array (Figure A) and resulting magnetic field gradient (Figure B) due to audible clicks administered with an earphone. The detector shows a response 100 milliseconds after the stimulus, as has been observed with liquid helium cooled sensors. Figure C shows the ability of the new detector to resolve a spatial profile of magnetic fields and Fig. D shows a picture of the apparatus with open magnetic shield door. *Credit: Michael Romalis, Princeton.*

► **Single Molecule Transistors**: By wiring a single molecule to electrodes, researchers at Arizona State directly measure electron transport through the molecule. They can also control the transport by switching the molecule between two forms that are called oxidized and reduced states. These results are among the most compelling in this competitive field and offer an unprecedented opportunity to understand how charges transfer through molecules – a phenomenon that plays vital roles in many chemical and biological processes. It is also a basic requirement toward the goal of building an electronic device using single molecules. (CHE)



Single molecule transistor system under development at Arizona State University. The top of the figure shows the schematic concept. *Credit: Nongjian Tao, Arizona State University.*

Other Performance Indicators

Number of People Involved in MPS Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	8,212	8,325	9,900
Other Professionals	2,000	2,025	2,400
Postdoctorates	2,171	2,200	2,600
Graduate Students	7,720	7,800	9,300
Undergraduate Students	6,091	6,150	7,300
K-12 Students	615	625	750
K-12 Teachers	478	485	550
Total Number of People	27,287	27,610	32,800

MPS Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	2,361	2,400	2,850
Funding Rate	32%	32	32
Statistics for Research Grants:			0.00
Number of Research Grants	1,848	1,875	2,200
Funding Rate	30%	30	30
Median Annualized Award Size	$105,912	$107,000	$107,000
Average Annualized Award Size	$130,459	$145,000	$145,000
Average Award Duration, in years	3.0	3.1	3.1

ASTRONOMICAL SCIENCES $250,010,000

The FY 2009 Request for the Astronomical Sciences Division (AST) is $250.01 million, an increase of $32.15 million, or 14.8 percent, over the FY 2008 Estimate of $217.86 million.

Astronomical Sciences Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Astronomical Sciences	**$215.39**	**$217.86**	**$250.01**	**$32.15**	**14.8%**
Major Components:					
Research and Education Grants	90.91	92.80	112.36	19.56	21.1%
Centers Programs	4.00	3.32	2.66	-0.66	-19.9%
Facilities	120.48	121.74	134.99	13.25	10.9%
Gemini Observatory	20.00	20.00	22.00	2.00	10.0%
National Astronomy and Ionosphere Center (NAIC)	10.46	10.45	9.60	-0.85	-8.1%
National Optical Astronomy Observatory (NOAO) [1]	39.28	38.55	41.83	3.28	8.5%
National Radio Astronomy Observatory (NRAO)	47.04	44.52	49.79	5.27	11.8%
Atacama large Milimeter Array (ALMA)	3.70	8.22	11.77	3.55	43.2%

Totals may not add due to rounding.

[1] Includes the National Solar Observatory and the Telescope System Instrumentation Program.

About AST:

AST is the federal steward for ground-based astronomy in the U.S. Research support covers a broad array of observational, theoretical, and laboratory research aimed at understanding the origins and characteristics of planets, the Sun, other stars, our galaxy, extragalactic objects, and the structure and origin of the Universe. Individual investigator awards and fellowship programs for young faculty, postdoctoral researchers, graduate students, and undergraduate students encourage researchers engaged in education and outreach and increase the participation of underrepresented minorities in science. AST provides the U.S. share of funding for the operation of the international Gemini Observatory and supports the operation of the National Astronomy facilities: NAIC; NOAO including the National Solar Observatory (NSO); and NRAO, including the U.S. share of the ALMA project. AST supports the development of advanced technologies and instrumentation and management of the electromagnetic spectrum for scientific use. In its quest to bring more powerful technology and a well-trained workforce to bear on the exploration of the universe, AST makes significant contributions to ACI.

The AST portfolio has two major modes of support: research and education grants and facilities.

- AST research and education grants range from awards to individual investigators to large collaborations carrying out extensive surveys or developing instrumentation.
- AST also supports major world-class facilities that provide access to a wide range of observational resources on a competitive basis.

Approximately 20 percent of the AST portfolio will be available for new research grants in FY 2009. The remainder of the funds will support continuing commitments on research grants from prior years, facilities (54 percent of the total), instrumentation, education and outreach, and centers. In FY 2007, AST received 670 research proposals and made 172 competitive awards for a success rate of 26 percent.

AST Priorities for FY 2009:

Research Grants are AST's highest priority in managing its portfolio. Emphasis will be on addressing scientific priorities articulated in the National Research Council's report "Astronomy and Astrophysics for the New Millennium" and the National Science and Technology Council report for the interagency "Physics of the Universe" activity, supporting work in cyberinfrastructure/ Cyber-Enabled Discovery and Innovation, including a national virtual observatory in partnership with NASA.

Activities related to ACI and ACA focus on using the strong connection to technology and instrumentation in the astronomical sciences to engage students and to promote workforce and career development. FY 2009 will see an increased emphasis in intermediate-scale instrumentation and development of university-based programs in instrumentation for students and faculty in collaboration with industry and national facilities (deferred in FY 2008 for lack of funds).

Public-Private Partnerships are a keystone of the division's strategy. In FY 2009, there will be continued investments in the **Telescope System Instrumentation Program** (TSIP) and **Giant Segmented Mirror Telescope** (GSMT) technology development, examples of such partnerships.

Gemini Observatory and ALMA operations and instrumentation are AST's highest priority in new research infrastructure. Ensuring optimum performance and future instrumentation of our premier and newest facilities enables forefront research by the community and their students in these international partnerships. Reallocation of funds within the facilities portfolio follows recommendations of the AST Senior Review, and optimizes the investment of scarce resources in highest priority capabilities.

Changes from FY 2008:

Research and education grants increase by $19.56 million to $112.36 million total. AST will continue to support a wide range of astrophysical investigations from the search for extra-solar planets to the origin of the universe. Development of tools for handling large data sets and implementation of the Virtual Astronomical Observatory in partnership with NASA are emphases in AST's approach to cyberinfrastructure/cyberscience. Education and outreach activities will receive continued emphasis. AST will continue support for technology development for the **Large-Aperture Synoptic Survey Telescope** (LSST).

Support for the **Science and Technology Center for Adaptive Optics** totals $2.66 million, a decrease of $660,000 over the FY 2008 Estimate. This lower funding level is planned as the STC sunsets.

Facilities increase by $13.25 million to $134.99 million total. Base operations funding for all facilities continue implementation of the recommendations of the AST Senior Review. See the Facilities chapter for details. Changes include:

- An increase of $2.0 million for **Gemini Observatory** will enable enhanced operational and visitor support and the funding of a new generation of advanced instrumentation.
- A decrease of $850,000 for **NAIC** reflects the recommendation of the Senior Review.
- An increase of $2.28 million for **NOAO/NSO** will enable infrastructure improvements, deferred in FY 2008, while design funding for the **Advanced Technology Solar Telescope** moves to the MREFC account. TSIP, administered through NOAO, increases by $1.0 million to $5.0 million, an increase originally planned for FY 2008. NRAO/ALMA funding totals $61.56 million, an increase of $8.82 million over FY 2008 Estimate, continuing the ramp up of ALMA operations.

CHEMISTRY $244,670,000

The FY 2009 Request for the Division of Chemistry (CHE) is $244.67 million, an increase of $50.45 million, or 26.0 percent, over the FY 2008 Estimate of $194.22 million.

Chemistry Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Chemistry	**$191.22**	**$194.22**	**$244.67**	**$50.45**	**26.0%**
Major Components:					
Research and Education Grants	167.51	165.61	201.88	36.27	21.9%
Centers Programs	9.60	13.42	25.26	11.84	88.2%
Instrumentation/Facilities	14.11	15.19	17.53	2.34	15.4%

Totals may not add due to rounding.

About CHE:

Chemistry is a bold and creative science that finds efficient ways to prepare Nature's compounds and to make new ones that have never existed before. Investment in basic molecular sciences is a major contributor to the $637 billion U.S. chemical industry. Approximately one third of the industrial output of the U.S. derives from the chemical industry, which in turn requires more than 2,000 PhD graduates per year to operate efficiently. The Chemistry Division plays a crucial role in the vitality of the basic research enterprise, especially in academic laboratories, and needs increased resources to sustain, expand and improve the community's ability to perform transformative and translational research in chemistry.

Approximately 50 percent of the CHE portfolio will be available for new research grants in FY 2009. The remainder will fund previous continuing commitments on grants, as well as grants for instrumentation and education. In FY 2007, CHE received 1,248 research proposals and made 341 competitive awards for a success rate of 27 percent.

CHE priorities for FY 2009:

The Centers for Chemical Innovation (CCI) program represents a new mode of support for transformative basic chemical research on "grand challenges." The CCI Program was initiated as a pilot in 2004 (as *Chemical Bonding Centers*) with several ambitious goals: to support high risk, transformative science; to energize the chemistry research community to tackle grand challenges; and to creatively engage the public. The change to *Centers for Chemical Innovation* reflects the addition of innovation as a key feature expected from these centers. Major themes from the ACI are targeted, such as sustainable technologies, nanotechnology, and molecular electronics.

ACI Fellows (ACI-F) in chemistry will provide consistent bridges across career transitions to the top ranked young talent in chemistry. ACI-F would launch young scientists into the professoriate – from their postdoctoral fellowship to their starting years as junior faculty. Goals include broadening participation and encouraging best practices in departmental culture. ACI-F will increase research capacity in targeted ACI areas such as nanotechnology and energy security.

Science and Engineering Beyond Moore's Law: One way to move beyond Moore's Law will use molecules or small assemblies of these as components of electronic devices. Ultimately, the goal is to develop a new generation of computer chips in which single molecules or small groups of them self-assemble into pre-designed structures to store information and function as devices. Intensive synthetic effort guided by rigorous theoretical studies is vital to accomplish the effort.

Quantum Information Science: Quantum computing using NMR spectroscopy and entangled states is an area of interest. Quantum effects in nanoparticles are being discovered and modeled effectively, which could find uses in information science and technology. If new paradigms of computing emerge as competitive technologies, the discoveries enabled by funding molecular electronics research will be crucial for successful implementation of these ideas.

Adaptive Systems Technology in CHE will use the chemical circuitry in cells as dynamic building blocks that are combined in precise ways to function, for example, as small chemical factories. The research would involve identifying chemical networks and their necessary vehicles and then inserting them biocompatibly in other cells or artificial structures. Recent advances have increased the capability to mimic and expand upon nature.

Transformational Facilities and Infrastructure: The Chemical Research Instrumentation and Facilities (CRIF) program has four tracks through which CHE addresses its priorities in Shared Instrumentation, Instrumentation Development, Facilities, and Cyberinfrastructure. A concerted effort to develop the next generation of *chemical imaging tools* will have a significant impact on our ability to understand complex biological processes, molecular electronics, chemical processes on catalytic surfaces, and environmental processes, as well as sensors for national security.

Cyber-enabled Discovery and Innovation: The goal of CDI-Chemistry is to stimulate new collaborations that will lead to transformative methods to model complex molecular structures, including excited electronic states. Systems of interest cross many scales of time, energy, and space and involve, for example, weak intermolecular interactions functioning in an environment composed of many thousands of solvent molecules. Development of multi-scale simulation methods for large numbers of interacting elements is at the forefront of simulation science.

Changes from FY 2008:

- CCI increases by $12.5 million to $20.0 million, reflecting the establishment of three additional Phase II centers and six new Phase I centers. Strong support is needed especially because of the budget reduction (one Phase II Center) in FY 2008.
- Other research and education grants increase by $36.27 million to a total of $201.99 million. $29.22 million is dedicated to subdisciplinary programs to fund curiosity-driven fundamental chemistry research. CHE will support: molecular electronics and Science and Engineering Beyond Moore's Law with an investment of $1.75 million; Quantum Information Sciences with $2.0 million; Adaptive Systems Technology with $1.0 million; Cyber-enabled Discovery and Innovation with an increase of $800,000; and ACI-Fellows with an increase of $1.50 million. The Science and Technology Center is phasing out, decreasing by $660,000.
- Funding for learning increases by $1.85 million to $11.93 million in a mix of individual and group activities ranging from undergraduates through professors. Discovery Corps Fellowship support will increase by $500,000 (postponed in FY 2008 due to budget constraints). Its focus will change to integration of research and service aimed at communicating chemistry's value to the public. Undergraduate Research Collaboratives will increase by $840,000 (program was postponed in FY 2008 due to budget); REU support will increase by $510,000.
- Instrumentation/Facilities increase by $2.34 million to a total of $17.53 million, including new investments in cyber-enabled chemistry, multi-user facilities, and instrument development for chemical imaging.

MATERIALS RESEARCH $324,590,000

The FY 2009 Request for the Materials Research Division (DMR) is $324.59 million, an increase of $64.37 million, or 24.7 percent, over the FY 2008 Estimate of $260.22 million.

Materials Research Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Materials Research	**$257.27**	**$260.22**	**$324.59**	**$64.37**	**24.7%**
Major Components:					
Research and Education Grants	146.96	149.51	192.88	43.37	29.0%
Centers Programs	70.19	70.69	79.69	9.00	12.7%
Facilities	40.12	40.02	52.02	12.00	30.0%
National High Magnetic Field Laboratory (NHMFL)	25.00	25.00	30.00	5.00	20.0%
National Nanofabrication Infrastructure Network (NNIN)	2.55	2.55	2.55	-	-
Other MPS Facilities	12.57	12.47	19.47	7.00	56.1%

Totals may not add due to rounding.

About DMR:

The Division of Materials Research advances the intellectual frontiers of materials research. The activities supported are a critical ACI component. DMR awards enable the science and engineering community to make new discoveries about the fundamental behavior of matter and materials; to create new materials and new knowledge about materials phenomena; to address questions about materials that often transcend traditional scientific and engineering disciplines and lead to new technologies; to prepare the next generation of materials researchers; to develop and support the instruments and facilities that are crucial to advance the field; and to share the excitement and significance of materials and condensed-matter science with the public at large.

- The division maintains a balanced portfolio of research topics through individual investigator grants, small groups, centers, and awards for instrumentation and user facilities, with considerable emphasis on interagency and international partnerships to advance materials research and education. DMR also supports six International Materials Institutes (IMI) based at U.S. universities to enhance international cooperation in materials, and a program to support the acquisition and development of instrumentation for materials research. Ten awards for Partnerships for Research and Education in Materials (PREM) are aimed at broadening participation in the materials research field. Both PREM and IMI competitions are planned for FY 2009.

- DMR Centers address major interdisciplinary problems in materials and condensed-matter science. DMR plans to support up to 29 Materials Research Science and Engineering Centers (MRSECs) in FY 2009; three MRSECs were phased out in FY 2007 based on results of the FY 2005 MRSEC competition. The division also supports three Nanoscale Science and Engineering Centers, provides partial support for a further seven NSECs, and supports two Science and Technology Centers.

- DMR supports world-class facilities for high magnetic fields, synchrotron radiation, and neutron scattering, and provides partial support for the National Nanofabrication Infrastructure Network. Researchers use these facilities to address challenging problems across a very broad range of disciplines including materials and condensed-matter science, physics, chemistry, biology, geosciences, and many areas of engineering.

Budget constraints in FY 2008 impacted primarily the following activities: The planned increase for the National High Magnetic Field Laboratory (NHMFL) and the planned support of new MRSECs for the FY 2008 competition could not be made. The requested FY 2009 budget will allow significant investments in these activities.

Approximately 15 percent of the funds requested for DMR in FY 2009 will be available for new competitive research grants; 4 percent will be available for new facility and instrumentation awards and 1 percent will support the planned increase in the funding for NHMFL. In addition, about 2.5 percent of the funds will be available for fully funding awards made in the FY 2009 MRSEC competition. An additional 2 percent of funds will support new transformative group awards that complement current DMR group and center awards. Remaining funds will support continuing commitments from prior years, facilities, instrumentation, and education and outreach. In FY 2007, DMR received 1,352 research proposals and made 301 research grants for a success rate of 22 percent for research grants.

DMR Priorities for FY 2009:

Support for materials research programs that explore new phenomena, develop novel materials, and undergird technological innovation. These programs include awards to individual investigators, interdisciplinary teams, and centers. Emphasis will be given to research on materials and phenomena at the nanoscale and the FY 2009 MPS and NSF-wide investments. Increased emphasis on international activities will lead to additional support for IMIs and enhanced support for research connections in the Pacific Rim.

Broadening participation in materials research. DMR will provide strong support for the participation of undergraduates, pre-college students, and pre-college teachers in research, and for increasing the support for partnerships that strengthen the links between institutions serving under-represented groups and DMR-supported research teams, centers, and facilities.

Maintaining support for world-class user facilities, while enabling the development of future user facilities and major instrumentation for synchrotron radiation, neutron scattering, and high magnetic fields.

Changes from FY 2008:

DMR will increase support for **research and education grants** by $43.37 million to a total of $192.88 million. Additional support will allow creation of the first set of transformative materials research groups that effectively bridge the gap between small groups of individual investigators and centers. There will be increased support for ACI Fellows.

DMR will increase support for **centers** by $9.0 million to a total of $79.69 million. This will provide full support for awards made as a result of the FY 2008 MRSEC competition and supplementary support for the Center for Environmental Issues in Nanotechnology expected to be awarded in FY 2008.

DMR will increase funding for facilities by $12.33 million to a total of $52.40 million. This will allow support of the NHMFL at the planned level. It will enable continued operational support for X-ray, neutron, and nanofabrication user facilities, and support for research and development necessary for the next generation of light source facilities.

MATHEMATICAL SCIENCES $245,700,000

The FY 2009 Request for the Mathematical Sciences Division (DMS) is $245.70 million, an increase of $33.91 million or 16 percent above the FY 2008 Estimate of $211.79 million.

Mathematical Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Mathematical Sciences	**$205.74**	**$211.79**	**$245.70**	**$33.91**	**16.0%**
Major Components:					
Research and Education Grants	205.74	211.79	245.60	33.81	16.0%
Centers Programs	-	-	0.10	0.10	N/A

Totals may not add due to rounding.

About DMS:

The Division of Mathematical Sciences (DMS) advances the intellectual frontiers of the mathematical sciences and enables the advance of knowledge in other scientific and engineering fields. It plays a key role in training the Nation's science and engineering workforce. Driven in part by increasingly sophisticated and readily available computing environments, advances in science and engineering require ever more sophisticated mathematical and statistical tools.

NSF plays a crucial role in support of basic academic research in the mathematical sciences, as it provides almost 60 percent of all federal university-based support. In the core mathematical areas this percentage is even higher, with NSF supporting a broader range of infrastructure and fundamental and multidisciplinary research topics than other federal agencies. DMS plays a dominant role in developing the next generation of mathematical scientists.

DMS supports areas such as algebra, analysis, applied mathematics, combinatorics, computational mathematics, foundations, geometry, mathematical biology, number theory, probability, statistics, and topology. In addition, DMS supports national mathematical science research institutes; infrastructure, including workshops, conferences, and equipment; and postdoctoral, graduate, and undergraduate training opportunities. The DMS portfolio includes a variety of support modes and mechanisms. These include:

- research grants ranging in scope from individual-investigator awards to awards for multidisciplinary groups of researchers to attack problems of mathematical and scientific importance.
- major support for education and training, particularly through Enhancing the Mathematical Sciences Workforce for the 21st Century, which focuses on research training in the mathematical sciences and mentoring activities aimed at increasing the number of U.S. students choosing careers in the mathematical sciences.
- core support for five mathematical sciences research institutes as well as major support for three other institutes, all funded on a competitive basis to serve as incubators for new ideas and directions in the mathematical sciences and to address the growing interface with other disciplines.

In FY 2009, approximately 61 percent of funds requested for DMS will be available for new research awards, with the remainder going to continuing commitments from earlier years. In FY 2007, DMS received 2,222 research proposals and made 769 awards, for a success rate of 35 percent.

DMS Priorities for FY 2009:

Fundamental mathematical and statistical science, including activities that strengthen the core of the discipline and enable effective partnering with other science and engineering disciplines. This is a central enabler of the ACI.

Interdisciplinary research and education, including key components of ACI where the mathematical sciences play a critical role in discovery for competitiveness and innovation:

- **Cyber-enabled Discovery and Innovation** uses the mathematical sciences to provide new ways of obtaining insight into the nature of complex phenomena in science and engineering.
- **Science and Engineering Beyond Moore's Law** continues the algorithmic "Moore's Law", – the exponential increase in speed of basic computations due to innovative new algorithms, in parallel with Moore's Law for hardware – and develops new mathematical frameworks for computation.
- **Quantum Information Sciences** involves research on quantum computing and communications including the understanding and implementation of algorithms in QIS.
- **MPS-Life Sciences Interface** provides mathematical language, methods, and tools to describe complex, multiscale, and emergent phenomena in the life sciences. This activity promotes the emergence of biology as a quantitative science and encourages bio-technological innovation.
- **Adaptive Systems Technologies** involves a multidisciplinary approach to using the architecture and operation of biological systems to achieve function and complex behavior in man-made adaptive systems. Discovery in this area would lead to innovation in such areas as robotics, sensor systems, specialized materials, and assistive devices.
- **ACI Fellows** improves the freshman and sophomore experience in mathematics through involvement in interdisciplinary, discovery-based activities. It is designed to strengthen the Nation's scientific workforce by increasing numbers of successful undergraduate majors in mathematics, science, and engineering.

Mathematical Sciences Research Institutes and Networks, the Workforce program, and **broadening participation at all levels in the mathematical sciences** remain high priorities for DMS.

Changes from FY 2008:

- **Support for the core** increases by $20.81 million, a significant portion of which will be used to further the aims of the ACI in part through interactions with other science and engineering disciplines and to restore cuts to division programs made in FY 2008. Award size and duration will be increased by providing adequate support for the most compelling projects and, to the extent possible, doing so without unduly reducing the success rate for unsolicited proposals.
- **Cyber-enabled Discovery and Innovation** increases by $3.85 million.
- **Science and Engineering Beyond Moore's Law** will be supported at $1.75 million.
- **Quantum Information Sciences** will be supported at the level of $2.0 million.
- **MPS-Life Sciences Interface** will be supported at the level of $1.0 million.
- **Adaptive Systems Technologies w**ill be supported at the level of $500,000.
- **ACI Fellows** will be supported at the level of $2.0 million.
- **Support for early career investigators** will increase by $2.0 million to a total of $8.16 million in order to increase the number of CAREER awards and to raise stipends for postdoctoral fellowships to a more competitive level.
- Support for the **Center for Research at the Interface of the Mathematical and Biological Sciences** will be $100,000. This will be matched by the MPS Office of Multidisciplinary Activities. This center is predominantly supported by the Directorate for Biological Sciences.

PHYSICS $ 297,700,000

The FY 2009 Request for the Physics Division (PHY) is $297.70 million, an increase of $47.18 million, or 18.8 percent, over the FY 2008 Estimate of $250.52 million.

Physics Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Physics	**$248.47**	**$250.52**	**$297.70**	**47.18**	**18.8%**
Major Components:					
Research and Education Grants	156.33	162.95	213.69	50.74	31.1%
Centers	7.68	6.36	6.36	-	-
Facilities	84.46	81.21	77.65	-3.56	-4.4%
Laser Interferometer Gravitational Wave Observatory	33.00	29.50	28.50	-1.00	-3.4%
Large Hadron Collider	18.00	18.00	18.00	-	-
IceCube Neutrino Observatory	0.25	1.50	2.15	0.65	43.3%
National Superconducting Cyclotron Laboratory	18.50	18.50	20.50	2.00	10.8%
Cornell Electron Storage Ring	14.71	13.71	8.50	-5.21	-38.0%

Totals may not add due to rounding.

About PHY:

PHY advances the intellectual frontiers of physics; contributes to advances in other scientific and engineering fields and to the ultimate benefit of the economy, health, and defense of the country; works toward early inspiration of the young, training the next generation of scientists and the high-tech workforce, and sharing the stimulation and understanding provided by science to the general public through the integration of research and education; and stewards the physics community to ensure it remains world-class as it evolves. PHY supports research over a broad range of physics subfields, including atomic, molecular, optical, and plasma physics; elementary particle physics; gravitational physics; nuclear physics; astrophysics; biological physics; physics at the information frontier; and theoretical physics and instrument development across all these subfields. The division maintains a balanced portfolio of research topics using appropriate modes of support and partnering across agency and national boundaries.

The PHY portfolio has two major modes of support: research and education grants and facilities.

- PHY research and education grants range in scope from individual-investigator awards to awards to major user groups, including groups with responsibility for experiments at national or international user facilities, and awards for frontier research efforts involving centers, institutes, and other multi-investigator collaborations.
- PHY also supports major world-class facilities needed by certain subfields to answer the highest priority science questions.

In FY 2009, approximately 35 percent of the funds requested will be available for new research grants, with the remainder going to continuing commitments from previous years and to facilities (approximately

30 percent of the portfolio), instrumentation, and education and outreach. In FY 2007, PHY made a total of 263 competitive research grants, for a funding rate of 39 percent for competitive actions.

PHY Priorities for FY 2009:

A strong, flexible program of research and education grants to create new ideas and technology and attract and train students is the highest priority in the PHY portfolio. Investments in FY 2009 will focus heavily on new directions grown out of earlier discoveries that show special promise to introduce revolutionary new technologies, especially those that derive from quantum control; to capitalize on modern grid technology and computational capabilities to develop new cyberinfrastructure to enable new discoveries and address increasingly complex scientific problems; and to more rapidly enhance support for emerging physics research on living systems. Support is provided through internal physics programs as well as joint participation with other parts of NSF, other agencies, and international partners.

Physics of the Universe (POU) continues to be a high priority within the Division. Research at this frontier addresses compelling questions at the interface of physics and astronomy in line with the joint investment plan between NSF, Department of Energy, and NASA put forth in the National Science and Technology Council report "The Physics of the Universe: A 21st Century Frontier for Discovery". Within NSF, POU is coordinated and supported by the AST and PHY Divisions. Activities include funding within grants programs, instrumentation development, and technical design for new facilities.

Changes from FY 2008:

Research and education grants increase by $50.74 million to a total of $220.05 million. PHY will enhance its support for ACI-related research in atomic, molecular, and optical physics, especially science beyond Moore's law ($1.75 million), physics at the information frontier, especially quantum information science ($3.0 million), cyberinfrastructure and cyber-enabled discovery ($1.20 million), and the physics of living systems ($2.0 million), with connections to Adaptive Systems Technology and the physical-life sciences interface. A mid-career ACI Fellows program ($1.0 million) will enhance the continuing emphasis on education and outreach activities and expanding diversity within the research community.

Facilities decrease by $3.56 million to a total of $77.65 million. For detail, see the Facilities chapter. This includes:

- Continued support for operations of the Laser Interferometer Gravitational Wave Observatory (LIGO) and for advanced detector R&D during startup of AdvLIGO construction at $28.50 million, a decrease of $1.0 million.
- Increased support for operations of the National Superconducting Cyclotron Laboratory (NSCL) radioactive ion beam facility to a total of $20.5 million, an increase of $2.0 million, back on plan after an unplanned $1.0 million reduction in FY 2008.
- Increased support for operations of IceCube to a total of $2.15 million from PHY, an increase of $650,000.
- Decreased support for the Cornell Electron Storage Ring (CESR) by $5.21 million to a total of $8.50 million as the continuation of the phase-out of operations as a high-energy research facility.
- Funding for instrumentation development and acquisition requiring investment at levels beyond the maximum limit of the agency-wide Major Research Infrastructure program or the resources of disciplinary programs will be increased by $3.35 million to a total of $8.50 million.

Support for technical design for the proposed Deep Underground Science and Engineering Laboratory (DUSEL) and R&D for detectors relevant to the proposed DUSEL will be increased by $6.0 million to a total of $10.0 million.

MULTIDISCIPLINARY ACTIVITIES $40,000,000

The FY 2009 Request for the Office of Multidisciplinary Activities (OMA) is $40.0 million, an increase of $7.30 million, or 22.3 percent, over the FY 2008 Estimate of $32.70 million.

Multidisciplinary Activities Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Multidisciplinary Activities	**$32.64**	**$32.70**	**$40.00**	**7.30**	**22.3%**
Major Component:					
Research and Education Grants	32.64	32.70	39.90	7.20	22.0%
Centers Programs	-	-	0.10	0.10	N/A

About OMA:

OMA enables and facilitates MPS support of particularly novel, challenging, or complex projects of varying scale in both research and education that are not readily accommodated by traditional organizational structures and procedures. This is done primarily in partnership with the five MPS disciplinary divisions to encourage multidisciplinary proposals from all segments of the MPS community and especially to encourage activities by multi-investigator, multidisciplinary teams pursuing problems on a scale that exceeds the capacity of individual investigators. Most often, these cooperative undertakings involve two or more partners – within MPS or beyond – that join with OMA to foster new directions of scientific understanding and that broaden and enrich education and research training activities in the MPS disciplines. Such partnerships are critically important to the pursuit of the strategic goals of NSF and of the MPS community and contribute significantly to the preparation of a diverse workforce for the new century that is broadly trained, flexible, and globally competitive. Facilitation by OMA of both disciplinary partnerships and organizational partnerships is vital to the accelerated discovery of new ideas, the development of new tools, and the broadened training necessary to enable the Nation’s workforce to meet new and rapidly evolving demands.

The portfolio of OMA is expanded this year to include some resources to address strategic planning for future facilities, again, in partnership with MPS divisions. This recognizes a long-standing need, as the costs for development of large projects are substantial and distort divisional budgets. This role is consistent with OMA primary function of enabling and facilitating complex projects with transformational scientific reach.

Because OMA plays a catalytic role in initiating new multidisciplinary activities and enabling broadening participation, the portfolio includes relatively few commitments from prior years. Approximately 37 percent of requested funds will be available for new research awards. Additional funds will be available for education grants and cooperative agreements supporting projects such as large centers and facilities. Most awards are managed in MPS divisions with co-funding from OMA.

OMA Priorities for FY 2009:

Enabling the creativity of and long-term impact of the MPS community by facilitating partnership-enabled multidisciplinary and high-risk research that extends the intellectual frontiers of the MPS disciplines. Such activities include fundamental multidisciplinary research at the interface between MPS and the life sciences that provides insights into the molecular basis of life processes, bio-inspired and biomimetic materials, and biological physics; research addressing the fundamental science that will be critical to move future computing and communications technologies beyond Moore's Law; cyber-enabled discovery and innovation; and team efforts by scientists, mathematicians, and engineers aiming to develop next-generation instrumentation, particularly at the mid-scale level, that enables fundamental advances across a wide spectrum of disciplines.

Catalyzing the development of a diverse, well-prepared, internationally competent, and globally engaged Science, Technology, Engineering, and Mathematics (STEM) workforce includes MPS participation in NSF-wide programs and in other activities that leverage the directorate's research investment. These activities enrich education and training at all levels and facilitate the formation of research-based partnerships that not only increase diversity and broaden participation in the STEM enterprise directly, but also build the physical and intellectual capacity of educational institutions, particularly minority serving institutions (MSIs), to produce larger, more diverse cohorts of graduates who are well prepared to both support and to lead the Nation's STEM enterprise in the 21st Century.

Changes from FY 2008:

- Funding for **broadening participation in the MPS disciplines**, including diversity-targeted partnerships involving minority-serving institutions and MPS-supported groups, centers and facilities, and diversity-building partnerships with MPS professional societies, increases by $1.50 million to a total of $5.0 million. These co-investments with the five disciplinary MPS divisions enable research-based collaborative activities primarily between MPS-supported research groups, centers and facilities, and MSIs. These collaborative interactions build research capacity of the MSI faculty; strengthen the research infrastructure of the MSIs; and engage, stimulate, retain, and develop an increasingly diverse cadre of students in the MPS disciplines at the undergraduate and graduate levels.
- Support for **collaborative public education and outreach** activities at MPS-supported research centers and facilities will be maintained at the FY 2008 level of $3.0 million. This investment supports activities that enable effective leveraging of the MPS research investment for public science education, and clear public articulation of crosscutting science themes with significant MPS involvement, such as cyber-enabled discovery and innovation and science and engineering beyond Moore's Law.
- The OMA investment in the **Research Experiences for Teachers** activity (RET) will be sustained at the FY 2008 level of $2.50 million, to provide more than 250 pre-service and in-service K-12 teachers with discovery-based learning experiences in the MPS disciplines. Support for the **NSF Graduate Teaching Fellows in K-12 Education** program will be maintained at the FY 2008 level of $3.0 million.
- Investment in cooperative **international research and training** will be increased by $200,000 to a total of $1.60 million to enhance the global competitiveness of U.S. scientists, engineers, and students.
- Investment in support of research addressing environmental health and safety aspects of **nanoscale science and engineering** will be increased by $500,000 to a total of $1.0 million.
- Investment in support of **cooperative activities between academic research groups and industry** will be increased by $750,000 to a total of $1.50 million.
- Support for the new **Center for Research at the Interface of the Mathematical and Biological Sciences** will be $100,000. This will be matched by funding from the MPS Division of Mathematical Sciences. This center is predominantly supported by the Directorate for Biological Sciences.

The above take place primarily in the context of **disciplinary and interdisciplinary research** and are strongly aligned with goals of the ACI and the America COMPETES Act**.** Increases in selected areas will be accomplished through a combination of new funds and the redirection of existing funds.

SOCIAL, BEHAVIORAL AND ECONOMIC SCIENCES $233,480,000

The FY 2009 Budget Request for the Directorate for Social, Behavioral and Economic Sciences (SBE) is $233.48 million, an increase of $18.35 million, or 8.5 percent, over the FY 2008 Estimate of $215.13 million.

Social, Behavioral and Economic Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Social and Economic Sciences	$99.86	$100.42	$107.49	$7.07	7.0%
Behavioral and Cognitive Sciences	84.64	84.63	92.78	8.15	9.6%
Science Resources Statistics	30.04	30.08	33.21	3.13	10.4%
Total, SBE	$214.54	$215.13	$233.48	$18.35	8.5%

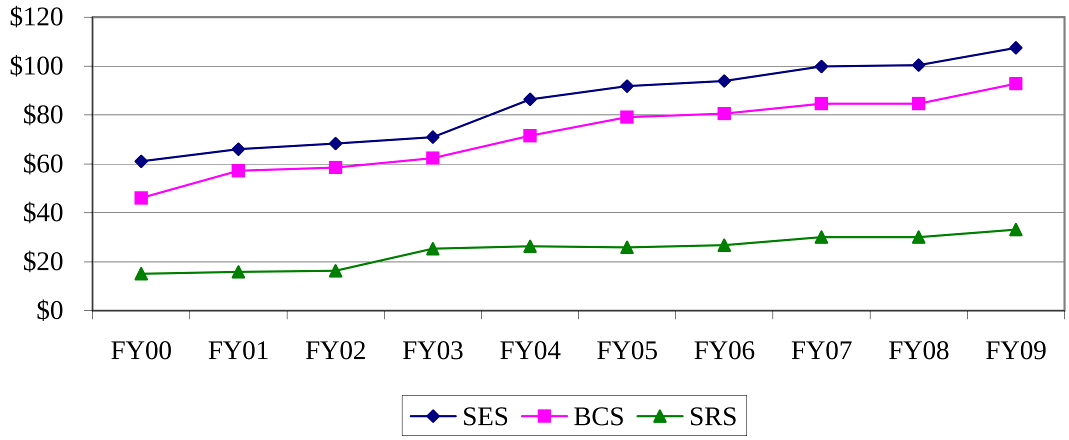
Totals may not add due to rounding.

The SBE Directorate supports fundamental research and related activities that yield new knowledge of human cognition, social organization, and patterns of development and change. In recent decades, SBE research has resulted in new understandings of human development and social dynamics; of perception, memory, linguistic, and reasoning processes; of how people behave as individuals and as members of groups and organizations; and of key social institutions and indicators.

The core of SBE activity addresses the dynamics of cognition, behavior, and social interactions that are important to developing such understanding. SBE’s growing program in the Science of Science and Innovation Policy (SciSIP) tackles the specifics of enhancing competitive processes in S&E. The data collections and analyses of the Division of Science Resources Statistics (SRS), the designated federal statistical entity with responsibility for the S&E enterprise writ large, are important for evaluating the progress of the American Competitiveness Initiative.

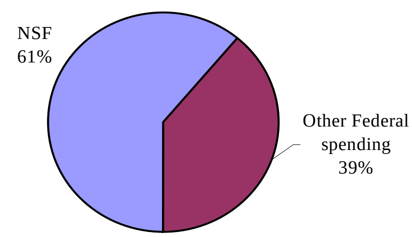
SBE participates in inter-directorate, interagency, and international research and education activities and encourages and supports many forms of transformative research. The portfolio includes novel connections among disciplines, contrarian research that challenges scientific orthodoxy, development or use of technologies such as functional magnetic resonance imaging (fMRI) and Geographical Information Systems (GIS), experiments with infrastructure for transformative research in the social sciences, rapid-response research on disruptive events, and engagement with urgent, real-world problems.

SBE Subactivity Funding
(Dollars in Millions)



RELEVANCE

Federal Support for Basic Research in the Social Sciences at Academic Institutions (excludes the Psychological Sciences)



SBE is a principal source of federal support for fundamental research on human cognition, behavior, social structures, and social interaction, as well as for research on the intellectual and social contexts that govern the development and use of science and technology. Overall, SBE accounts for 61 percent of federal support for basic research in the social sciences at U. S. academic institutions, excluding the psychological sciences. In some fields, including archaeology, political science, linguistics, and non-medical anthropology and sociology, SBE is the predominant or exclusive source of federal basic research support. SBE provides approximately one percent of federal support for basic research in the psychological sciences to U.S. academic institutions; from that small fraction, it provides predominant federal support for the social aspects of psychology.

Over the past decade, three key elements have caused research in the SBE sciences to undergo dramatic changes. First, new technologies, analytical techniques, and cyber capabilities have been critical. For example, fMRI techniques have enabled behavioral scientists to link behavior to brain activity, opening new channels for investigation, and the integration of GIS into existing and novel analyses has provided new spatial data and new insights, since why something happens is often a function of where it happens.

Second, these new analytical techniques and enhanced cyber capabilities have combined with more traditional technological change to create new approaches to shared infrastructure for the SBE sciences, making survey information and databases more broadly accessible and enabling linkages across datasets collected for different purposes. This new infrastructure yields finer resolution of phenomena and enhanced ability to explore complexity in human systems across a broad spectrum of research areas.

Simultaneously, NSF's strong emphasis on partnerships for exploring human and social dynamics has provided the third key element for progress in the SBE sciences. The Human and Social Dynamics (HSD) Priority Area focused on exploring the processes and implications of constantly changing systems, along with partners across NSF who share an interest in the way human and social behavior interacts with natural and built systems and mediates the interaction between basic research results and marketable technologies. While the Priority Area ends in FY 2008, the research activities it stimulated will continue to flourish through enhanced core programs, SBE emphases and participation in NSF-wide and interagency activities.

SBE is well positioned to contribute to major national challenges, including addressing human and social aspects of new technologies. SBE will continue to support government-wide activities such as the National Nanotechnology Initiative (NNI), the Climate Change Science Program (CCSP), and the Networking and Information Technology Research and Development (NITRD) program, and will continue to support the administration's programmatic priorities relating to homeland security. SBE will participate in the newly formed cross-Foundational Adaptive Systems Technology (AST) investment through research principally dealing with brain functions that yield insights into how nature provides models for engineered systems; it will make further investments in NSF's Cyber-enabled Discovery and Innovation (CDI) investment, focusing on the tipping points and emergent phenomena that permeate the human sciences and are characteristic of SBE work on complexity and interacting systems; it will maintain its support for Cyberinfrastructure related-activities; and will fund multi-directorate activities that investigate the human dimensions of environmental phenomena, such as climate change or water supply and quality, and the social and ethical issues that surround nanotechnology. Another multi-directorate partnership of recently funded research emerged from the HSD Priority Area, and it is NSF's first cross-directorate (SBE, BIO, and GEO) standing program – the Dynamics of Coupled Natural and Human Systems (CNH). Cross-disciplinary teams of scientists and engineers are brought together to discover the complex interactions between human and natural systems that drive the most pressing environmental problems for our Nation and the world.

Other topics of recently funded research include brain activity associated with the integration of thought and emotion, complex responses to stressors, and discerning truth from deception; scientific understanding of factors affecting low participation in science, technology, education, and mathematics (STEM); documenting endangered languages; the influence of fear on perceptions and decision making; agent-based and network modeling; and the effects of terrorist assaults and natural disasters on people directly affected as well as those removed from physical harm but emotionally engaged with the victims.

SBE's SRS Division conducts, analyzes, and disseminates survey results relating to R&D funding and facilities, the S&E workforce, and the education of scientists and engineers. SRS also gathers information on the international S&E enterprise and uses available information to describe the U.S. S&E role in a globalized economy. In FY 2009, SRS will develop a pilot data collection on postdoc activities; will implement a full-scale pilot of a major and much-needed redesign of the Survey of Industrial R&D, which has been renamed to the Business Research and Development Survey; and will support data extraction activities. SRS activities, products, and services provide critical benchmarking information on R&D, the S&E workforce, and the outputs of the S&E enterprise such as patents and scientific publications. SRS provides access to a variety of data on S&E through its website (www.nsf.gov/statistics) and online databases.

SBE has long contributed to addressing national challenges. In FY 2009, SBE is well positioned to make even more significant contributions in partnership with other agencies and with other NSF directorates.

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, SBE……………….……………………………………….………..........................$215.13

Social and Economic Sciences (SES) +$7.07

Increased funding will strengthen core social science programs through targeted investments in potentially transformative research areas and will support SciSIP research contributing to design of new metrics of science and interdisciplinary collaborations. There will be a focus on data resources, analytical tools, mathematical applications, and increased theoretical engagement. Further investments in CDI will emphasize applications of complexity and systems thinking.

Behavioral and Cognitive Sciences (BCS) +$8.15

Increased funding will strengthen the basic research enterprise and encourage transformative research in the behavioral, cognitive, anthropological, and geographic sciences through enhancement of the support provided to core; will increase fundamental knowledge about complexity and develop systems models of human thought and behavior; will contribute further to the CDI investment and SciSIP; and will advance understanding of the interplay among physical systems, brains, and human intelligence through the cross-foundational AST investment

Science Resources Statistics (SRS) +$3.13

Increased funding will focus on SciSIP: implementation of a full-scale pilot of a redesigned Survey of Industrial Research and Development, (now renamed as the Business Research and Development Survey), and a pilot data collection on postdoc activities.

Subtotal, Changes +$18.35

FY 2009 Request, SBE...$233.48

Summary of Major Changes by Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, SBE……….……………………………………….………..............................$215.13

<u>Discovery</u> +14.12

- *Strengthening the Core (+$6.96 million).* SBE investments in fundamental research will continue to advance the frontiers of social, behavioral, and economic sciences by supporting research across traditional boundaries, encouraging interdisciplinary and international research at the frontiers of discovery across all its fields.

- *Science of Science and Innovation Policy (+$3.12 million).* $2.19 million will support interdisciplinary research collaborations that promote global and comparative understanding of the dynamics of science and technology, including funding for SciSIP-related interdisciplinary collaboratories and data extraction research. $930,000 supports fundamental research on improved and expanded science metrics, datasets, and analytical tools to assess the impacts and improve understanding of the dynamics of the Nation’s S&E.

- *Complexity and Systems Thinking in the Human Sciences (+$3.0 million).* $1.58 million will fund CDI work on complexity and systems models of human thought and behavior as well as social organizations, institutions, and processes, bringing the FY 2009 CDI investment to a total of $2.58 million. Such work promises to transform analysis and understanding by reconceptualizing fundamental behaviors and processes and by revealing the emergent properties of dynamic systems. System models of this sort seek to explain, for example, those "tipping points" where gradual, long-term patterns of change abruptly produce large-scale structural changes, such as the collapse of economic markets, transformation of languages, evolutionary changes, explosive scientific developments, stampeding crowds, riots or insurrections, and other disruptive events. Structural changes of this kind pose fundamental challenges to existing theories and create opportunities for fresh and insightful new thinking. Funding will also support work on human causes and consequences of environmental change, including short-term disruptive weather events and long-term climate change. This will encompass work on economic models, decision making, land use, and changes in water quality and supply.

- *Adaptive Systems Technology (+$1.04 million).* This new multi-directorate investment seeks to develop new technologies based on a better understanding of biological and particularly neurological systems. In the SBE context, this involves applying and expanding what we know from cognitive and learning science, the central subject matter of our programs in Developmental and Learning Sciences; Perception, Action and Cognition; Cognitive Neuroscience; Linguistics; and the Science of Learning Centers.

<u>Learning</u> +$0.16

Research Experiences for Undergraduates (REU)
Support for the REU Sites increases by $160,000, to a total of $1.70 million.

<u>Research Infrastructure</u> +$3.02

Funding will allow SRS to contribute to SciSIP by improving and expanding science metrics datasets, data extraction activities, and analytical tools from which researchers and policymakers may assess impacts and improve their understanding of the dynamics of the Nation's S&E enterprise.

<u>Stewardship</u> +$1.05

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$18.35

FY 2009 Request, SBE…….……………………….……….………………….………………..............$233.48

NSF-WIDE INVESTMENTS

In FY 2009, the SBE Directorate will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Adaptive Systems Technology	-	-	$1.04	$1.04	N/A
Biocomplexity in the Environment	3.92	-	-	-	N/A
Climate Change Science Program	15.50	15.48	15.48	-	-
Cyber-enabled Discovery and Innovation	-	1.00	2.58	1.58	158.0%
Cyberinfrastructure	20.60	20.54	20.54	-	-
Human and Social Dynamics	31.87	31.40	-	-31.40	-100.0%
International Polar Year	3.01	2.00	-	-2.00	-100.0%
Mathematical Sciences	0.75	-	-	-	N/A
National Nanotechnology Initiative	1.67	1.67	1.67	-	-
Networking and Information Technology R&D	12.47	13.47	15.05	1.58	11.7%

Adaptive Systems Technology (AST): In relation to the agency's Adaptive Systems Technology goal "*to generate creative pathways and natural interfaces between human and physical systems that will revolutionize the development of novel adaptive systems*", SBE's initial investment of $1.04 million will advance understanding about the interplay among physical systems, brains, and human cognition, with research focused on developing new collaborations, approaches, and imaging techniques to discover the brain mechanisms involved in the cognitive functions of language, perception, memory, and emotion.

Biocomplexity in the Environment (BE) and Mathematical Sciences (MS): With the conclusion of these priority areas in FY 2007 or FY 2008, key components of these investments are retained for core programs.

Climate Change Science Program (CCSP): Support for CCSP remains level with the FY 2008 Estimate at $15.48 million. SBE's CCSP investments focus on the "Human Contributions and Responses" that explain how people (individually, in groups and communities, or through organizations) interact with natural environmental systems to influence or adapt to climate and weather changes. Work in this area will be strengthen by the CDI investments to develop complexity and system models of socio-ecological processes, by the reallocation of HSD resources supporting work on the environment, and by participation in the interdirectorate CNH program.

Cyber-enabled Discovery and Innovation (CDI): CDI funding increases by $1.58 million, the same amount as NITRD (see below), bringing the FY 2009 investment to a total of $2.58 million. CDI includes three themes for FY 2009, all of which are central to SBE goals: 1) From Data to Knowledge, 2) Understanding Complexity in Natural, Built, and Social Systems, and 3) Virtual Organizations. Funding for CDI will increase work on complexity and systems models of human thought and behavior as well as social organizations, institutions, and processes. Such approaches promise to transform analysis and understanding by reconceptualizing fundamental behaviors and processes and by revealing the emergent properties of dynamic systems.

Cyberinfrastructure (CI): Cyberinfrastructure support remains at $20.54 million, level with the FY 2008 Estimate. Investments will be made in major social and behavioral science data collections and will address issues such as confidentiality protections and means for securing worldwide, user-friendly access. Breakthrough technologies, large-scale data capture, and the capacities of high performance computing will enable SBE sciences to grapple with and model complexity in ways that were heretofore impossible. Added investments will prepare scientists and educators to design, develop, and use cyberinfrastructure to enhance research in the social and behavioral sciences.

Human and Social Dynamics (HSD): With the conclusion of the HSD investment area, SBE will redirect its resources to core programs. HSD was designed to foster synergies across the social and behavioral sciences and with other fields of S&E by supporting multidisciplinary approaches to understanding the complex dynamics involving human and social systems and their environments, at scales ranging from cellular to global and from nanoseconds to millennia. HSD aimed to increase our ability to anticipate the complex consequences of change, to understand the cognitive and social structures that create and define change, and to help people and organizations manage profound or rapid change. Three of the productive areas emerging from HSD are work on the interactions between humans and environmental systems, work on complexity and systems thinking, and developing infrastructure. These areas will continue to be fostered by SBE investments through its core research programs.

International Polar Year (IPY): With the conclusion of IPY in March 2009, key components of this investment will be retained for core programs.

National Nanotechnology Initiative (NNI): Support for NNI is maintained at $1.67 million and enables research and educational activities that focus on issues of nanotechnology R&D and societal consequences, on both a domestic and global scale.

Networking and Information Technology Research and Development (NITRD): NITRD funding increases by $1.58 million, the same amount as CDI (see above), bringing the FY 2009 investment to a total of $15.05 million.

QUALITY

SBE maximizes the quality of R&D it supports through the use of a competitive, merit-based review process. In FY 2007, the last year for which complete data exist, 98 percent of research funds were allocated to projects that underwent external merit review.

To ensure the quality of its processes for handling proposals and recommending proposals for awards, SBE convenes Committees of Visitors (COV) composed of expert external evaluators to review each program every three years. These experts assess the integrity and efficiency of the proposal review process and provide a retrospective assessment of the results of NSF's SBE investments. COVs are scheduled for both BCS and SRS Divisions in FY 2009 and the SES Division COV is scheduled for FY 2010.

The directorate also receives advice from the Social, Behavioral and Economic Sciences Advisory Committee (SBEAC) on the missions, programs, and goals that best serve the scientific community; the promotion of quality graduate and undergraduate education in the social, behavioral, and economic sciences; and investment areas for research. The SBEAC typically meets twice a year and its Chair regularly consults with the SBE Assistant Director. Members represent a cross-section of supported disciplines, with representatives from many sub-disciplines and members from academic institutions and industry. SBEAC includes women, underrepresented groups, and people from all geographic regions of the U.S.

SRS has undertaken a number of activities to improve the quality, timeliness, accuracy and relevance of its data and analyses. Based on the recommendations of the NRC report *Measuring Research and Development Expenditures in the U.S. Economy* and the recommendations of the 2006 COV of SRS personnel data, the Division has undertaken a major effort to redesign a number of its surveys to improve their ability to depict the state of the S&E enterprise in the 21st century. SRS, as a federal statistical agency, also strives to implement the OMB quality standards for data collections, confidentiality, and dissemination. SRS has a set of quality standards that cover all stages of data collection, analysis, and dissemination.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Social, Behavioral and Economic Sciences
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Discovery	$166.06	$165.21	$179.33	$14.12	8.5%
Learning	9.82	9.27	9.43	0.16	1.7%
Research Infrastructure	35.58	36.85	39.87	3.02	8.2%
Stewardship	3.09	3.80	4.85	1.05	27.6%
Total, SBE	$214.54	$215.13	$233.48	$18.35	8.5%

Totals may not add due to rounding.

Recent Research Highlights

► **Producing a Bureau of Economic Analysis/NSF Research and Development Satellite Account with Methodological Improvements:** A research partnership of the Bureau of Economic Analysis, which is responsible for developing Gross Domestic Product (GDP) estimates, and Science Resources Statistics (SRS), the federal statistical agency at NSF responsible for producing research and development (R&D) statistics for the U.S., has resulted in the creation of an R&D satellite account. The satellite account treats R&D as an investment and recognizes it as a stock of intangible capital, paralleling the treatment of expenditures on structures and durable equipment as a stock of tangible capital. Incorporating R&D expenditures into the national accounts permits ready analysis of R&D in the context of GDP and its components and allows the construction of models to estimate the impact of R&D on GDP, productivity, and other macroeconomic aggregates. The effort required extensive statistical enhancements to the original R&D data to make them consistent with national accounting methodologies. (SRS)

► **Revealing Hominid Origins: Finding Lucy's Ancestors:** The Middle Awash research team in Ethiopia's desolate Afar region is investigating a kilometer-thick deposit of sediments that accumulated over the last 6 million years. The team's latest discoveries of prehistoric fossils reveal a 4 million year-old African landscape inhabited by human ancestors much older than the famous "Lucy" specimen. The fossils illuminate the origin of the "ape-man" genus Australopithecus and represent an evolutionary link to the still-older remains of Ardipithecus found previously in the same area. The thirty fossils of ancient humans (hominids) include jaws, teeth, and skeletal parts that show that these hominids practiced two-legged locomotion. Micro-CT technology revealed that the cheek teeth were adapted to heavier chewing than those of earlier hominids. However, associated fossils of rodents, monkeys, and antelopes show that early hominids lived and died in well-watered, wooded habitats for millions of years in this part of Africa. This new evidence indicates that the long-favored "savannah" model of human evolution should be abandoned. (BCS)

Our Early Ancestors. *Credit: Tim White.*

► **International Integrated Microdata Series:** A project to preserve and harmonize global census microdata and make it freely accessible to researchers worldwide is now the largest public-use population database in the world. The database includes microdata from more than 80 censuses, for 26 countries, and more than 200 million individuals and will grow at least 500 percent over the next decade. The infrastructure provides a data archive and translates all documentation into English, fully documents comparability issues regarding census questions, and codes the data consistently to facilitate international comparisons. Social and behavioral scientists use the census microdata to study large-scale transformational changes, such as urbanization, economic development, migration, and population aging. They also assess relationships of social and economic change to variations in climate, geography, and environment. Such data can be used to study the human consequences of social, economic, and demographic transitions in diverse areas such as family structure, economic inequality, cultural diversity, and assimilation. More than 2,500 social science researchers use the database, and 2,274 publications cite the database. (SES)

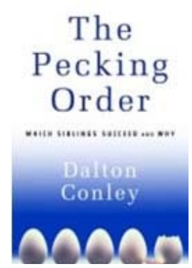
Integrated Public Use Microdata Series (IPUMS). *Credit: The National Science Foundation.*

► **Understanding and Overcoming Social Psychological Barriers to Academic Development:** Cutting edge research in social psychology explains why women and underrepresented minorities have lower levels of achievement relative to men and majority group members, respectively. The reason is "stereotype vulnerability," and NSF-supported research shows how it impacts the performance of women and ethnic minorities within science, technology, engineering, and mathematics fields. It occurs when members of a group believe in negative stereotypes about their abilities, thereby lowering performance. New research identifies situations that give rise to stereotype vulnerability, the factors that moderate it, and its consequences for achievement. When stereotype vulnerability is removed, performance is no

Stereotype vulnerabilities can occur in ordinary classroom settings. *Credit: Courtesy of Richard F. Voss and Heinz-Otto Peitgen.*

longer impaired, and women and ethnic minorities perform at rates comparable to men and majority members. Research on stereotype vulnerability has led to important interventions that have raised the achievement and test scores of low performing women and minority students. (BCS)

► **The Pecking Order: Inequality and Family in the U.S.:** Fifty or more years of research into the pattern and dynamics of economic inequality in the U.S. has focused upon the influence of family origins on children's outcomes. The fundamental model held that the advantages of highly-paid professional work were generally conferred upon children, and empirical investigations focused on measuring the magnitude of influence, comparing effects for sons and daughters, for African Americans and Caucasians. But this research overlooked the inconvenient fact that there is much more economic inequality between siblings from the same family than there is between families of different origins. New research shows that growing up within a family is a different experience for different children, with materially different consequences for their lives. Genetics and birth order do not explain these differences. Instead, family size, family structure, and patterns of interaction within the family combine to create a pecking order within families that benefits some children at the expense of others. (SES)



The Pecking Order: Inequality and Family in the U.S. *Credit: Dalton Conley.*

► **The Role of Individual Decision Making in Influenza Vaccination Policy:** Researchers are using game theory to study how individuals' voluntary vaccination decisions influence the spread of infectious diseases. They tested whether subjects' vaccination choices correspond to those that maximize their individual advantage and whether voluntary vaccination decision-making results in a Nash equilibrium outcome - a societal outcome where no individual has anything to gain by changing his/her strategy unilaterally.

A Red Cross volunteer drawing blood to be tested for its concentration of antibodies during an influenza outbreak. *Credit: Janet Astor of Centers for Disease Control and Prevention.*

They examined the vaccination decisions of more than 600 subjects. They discovered that persons aged 65 and older are most likely to get influenza vaccinations, while immunization rates for the young were very low. Unfortunately, such decisions, made purely based on one's own self interest result in thousands or, in the case of pandemics, millions of deaths each year. The reason is simple: the young are disproportionately responsible for spreading infectious diseases and they are the ones choosing not to get immunized. A utilitarian policy that relied on community-wide programs to vaccinate younger members of the population would be more effective in reducing the spread of infectious diseases. This research has implications for policy-makers and public health practitioners trying to plan and implement preventative health efforts to achieve the greatest societal benefit. (SES)

Other Performance Indicators

The tables below show the estimated number of people benefiting from SBE funding, trends in award size and duration, number of awards, and funding rates.

Number of People Involved in SBE Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	2,881	2,886	3,018
Other Professionals	487	490	517
Postdoctorates	189	192	212
Graduate Students	1,668	1,673	1,693
Undergraduate Students	1,431	1,436	1,450
K-12 Teachers	-	-	-
Total Number of People	6,656	6,677	6,890

SBE Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	1,143	1,148	1,277
Funding Rate	27%	27%	27%
Statistics for Research Grants:			
Number of Research Grants	676	680	810
Funding Rate	22%	22%	24%
Median Annualized Award Size	$93,851	$94,000	$95,880
Average Annualized Award Size	$115,337	$115,550	$117,810
Average Award Duration, in years	2.5	2.5	2.5

SOCIAL AND ECONOMIC SCIENCES $107,490,000

The FY 2009 Budget Request for the Division of Social and Economics Sciences (SES) is $107.49 million, an increase of $7.07 million, or 7.0 percent, over the FY 2008 Estimate of $100.42 million.

Social and Economic Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Social and Economic Sciences	**$99.86**	**$100.42**	**$107.49**	**$7.07**	**7.0%**
Major Components:					
Research and Education Projects	99.86	100.42	107.49	7.07	7.0%

Totals may not add due to rounding.

About SES:

SES supports research and related activities, conducted within the U.S. and globally, to improve systematic understanding of political, economic, and social institutions and how individuals and organizations behave within them. It also supports research and other activities related to risk assessment and decision making by individuals and groups; the nature and development of the various sciences and technologies and their implications for society; methods and statistics applicable across the social, economic, and behavioral sciences; scholarly career development; and broadening participation in the social, behavioral, and economic sciences. Its programs include the established disciplines of economics, political science, and sociology, and such vibrant interdisciplinary fields as decision making and risk, law and social science, and science and technology studies. In many of its program areas, SES is the major (sometimes only) source of federal funding for fundamental research, and SES is a principal investor in the data resources and methodological advances that produce transformative research.

In general, 56 percent of the SES portfolio is available for new research grants. The remaining 44 percent is used primarily to fund continuing grants made in previous years. SES supports research and education through grants that range in size from small supplements for undergraduates to collaborate with faculty on research projects to multi-million-dollar survey awards such as the *Panel Study of Income Dynamics*, the *American National Elections Studies*, and the *General Social Survey*. These surveys are national resources for research and decision making that have become models for similar efforts in other societies.

SES is strengthening these surveys through investments in cyberinfrastructure that increase response rates, improve quality, and shorten the time required to design, field, and analyze questionnaire surveys. The Time-sharing Experiments for the Social Sciences (TESS) uses the internet as a medium for conducting survey-based experiments. Not only does TESS allow innovative research design, it also widens access to high-quality survey data and lowers the research costs for participating investigators.

SES leads Foundation-wide efforts to understand the ethical, legal, and social dimensions of science, engineering, and technology by coordinating the Ethics Education in S&E Program, by supporting (with other NSF directorates) the Online Ethics Center for Engineering and Science, and by managing the Centers for Nanotechnology in Society. These collaborative activities contribute to the education of scientists and engineers and shape the trajectory of research and development.

SES Priorities for FY 2009:

- Strengthen core social science programs through targeted investments in potentially transformative research areas. Data resources, analytic tools, mathematical applications, and opportunities for integrative theory and research are growing dramatically across the social sciences, and increases in core programs will be used to stimulate and sustain such activities. In particular, SES will increase support for research that creates or employs advanced qualitative and quantitative methods and for studies of the origin, shaping, and uses of science, knowledge, and technology.
- Support research in the Foundation-wide investment area of CDI, with particular emphasis on applications of complexity and systems thinking to the human sciences. Applications of computation and related cyber-technologies will open new vistas for the social and economic sciences by mining, analyzing, and aggregating behaviors and transactions that had been inaccessible. Social and economic phenomena are inherently complex, because they include patterns and structures that only emerge through the accumulation of individual decisions and actions that occur over space, time and populations. Complexity and interacting system have transformative potential across the spectrum of social and economic sciences, so support for such work will be integral to the development of those fields.
- Increase support for administrative activities essential for the division to achieve its strategic goals.

Changes from FY 2008:

Support for the SES Division increases by $7.07 million to a total of $107.49 million:

- $5.01 million will strengthen fundamental research in core programs that has transformative potential for the social and economic sciences and will support SciSIP interdisciplinary research. SES will give particular emphasis to the development and application of advanced qualitative and quantitative methods and to research that addresses the origin, shaping, and uses of science, knowledge, and technology.
- $1.50 million will fund research on complexity and interacting systems in the social and economic sciences. Of this, $790,000 will increase support for SBE-related investments in CDI through programmatic funding for applications of computational and complexity thinking to the most challenging scientific problems in the human sciences, including the fundamental problems in economics, decision making, and methodology that underlie the human causes and consequences of disruptive weather events, long-term climate change, and the consumption of scarce natural resources.
- $80,000 will provide additional support for REU Sites.
- $480,000 will support administrative activities essential for the division to achieve its strategic goals.

BEHAVIORAL AND COGNITIVE SCIENCES $92,780,000

The FY 2009 Budget Request for the Division of Behavioral and Cognitive Sciences (BCS) is $92.78 million, an increase of $8.15 million, or 9.6 percent, over the FY 2008 Estimate of $84.63 million.

Behavioral and Cognitive Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Behavioral and Cognitive Sciences	**$84.64**	**$84.63**	**$92.78**	**$8.15**	**9.6%**
Major Components:					
Research and Education Projects	84.64	84.63	92.78	8.15	9.6%

Totals may not add due to rounding.

About BCS:

BCS supports research and related activities that advance fundamental understanding in the behavioral, cognitive, anthropological, and geographic sciences. The division seeks to develop and advance scientific knowledge and methods focusing on human cognition and behavior including perception, thought processes, language, learning, and social behavior across neural, individual, family, and group levels. The division supports research and related activities that focus on human variation at the scales of society, culture, and biology as well as how these variations and related patterns develop over time scales ranging from milliseconds to millennia. The division also supports efforts to increase basic understanding of and capabilities to explore geographic distributions and relationships, with an emphasis on interactions of human, physical, and environmental systems on the Earth's surface. Strong core programs are complemented by active involvement in competitions that support collaborative and cross-disciplinary projects to advance knowledge and build capacity by bridging multiple fields.

In general, 71 percent of the BCS portfolio is available for new research grants. The remaining 29 percent is used primarily to fund continuing grants made in previous years. The BCS portfolio mainly supports research and education grants ranging in scope from dissertation and individual-investigator awards to larger group projects that span multiple disciplines and institutions. Major activities include:

- Understanding fundamental human processes including language, cognition, perception, reasoning, and action planning in relation to adult and childhood developmental processes;
- Providing fundamental understanding of human social behavior including attitude formation and change, social cognition, affective and motivational influences, and personality processes;
- Integrating qualitative and quantitative analyses to better understand cultures;
- Understanding human biological variation, adaptation, and ontology;
- Using a geographic framework for understanding social, political, and economic transformations;
- Facilitating research to address the complexity in human-environmental interactions;
- Using non-linear models to understand dynamics of human behavior;
- Documenting the world's endangered languages in order to preserve retrievable information about linguistic structures; and
- Creating platforms for annotating and archiving textual, audio, and video language samples, as well as accessing the material for analyses.

BCS will continue to place emphasis on integrating findings from multiple perspectives to elucidate how human beings think, learn, and behave as individuals and as members of various socially and culturally-defined groups. Through support of basic research, the behavioral and cognitive sciences are advancing knowledge about the relations between brain and thought processes, between individual differences and cultural contexts, and between human and environmental systems. As examples, BCS research is helping us to prepare for and mitigate the effects of natural and human-initiated disasters, to predict and address how people respond to stressors, to improve methods for effective learning, to enhance the quality of social interaction, and to respond to issues such as globalization, terrorism, and climate change.

Ongoing activities within BCS include documenting endangered languages, understanding child learning, studying human origins, and understanding the interplay between humans and the environment. Cyberinfrastructure investments will continue to provide significant opportunities for breakthroughs in cognitive and behavioral sciences. New methods are transforming how we understand the links between behavior, cognition, and their biological substrates. These advances are strengthening the core programs and their relations to each other.

BCS Priorities for FY 2009:

- Strengthen the basic research enterprise and encourage transformative research in the behavioral, cognitive, anthropological, linguistic, and geographic sciences through increased support to core programs that serve these critical research communities. In particular, BCS will emphasize additional funding in areas that are expanding in new directions and increasing cross-disciplinary interactions, such as social cognition, human-environment interactions, and SciSIP.
- Increase fundamental knowledge about complexity and develop systems models of human thought and behavior. Attention will be given to research that examines the full range of interactions that occur across scales ranging from synapses and cells through individuals and groups to global-scale phenomena, with special emphasis placed on surprising non-linear relationships.
- Advance understanding about the interplay among physical systems, brains, and human intelligence, with research focused on developing new collaborations, approaches, and imaging techniques to discover the brain mechanisms involved in the cognitive functions of language, perception, memory, and emotion.

Changes from FY 2008:

Support for the BCS Division increases by $8.15 million to a total of $92.78:

- $5.07 million will strengthen core disciplinary research to enhance the number of transformative projects in areas that expand in new directions and increase cross-disciplinary interactions, including SciSIP-related research.
- $1.50 million will fund research on complexity and interacting systems in the behavioral, cognitive, anthropological, and geographic sciences. Of this, $790,000 will fund SBE-related investments in the CDI activity, and a portion will support environmental research for work on human causes and consequences of environmental change,
- $1.04 million will support Adaptive Systems Technology research in cognitive and behavioral processes, including research on language, learning, social processes, cognition, and higher-order perception.
- $80,000 will provide additional support for REU Sites.
- $460,000 will support administrative activities necessary to enable BCS to achieve NSF's strategic goals.

SCIENCE RESOURCES STATISTICS $33,210,000

The FY 2009 Budget Request for the Division of Science Resources Statistics (SRS) is $33.21 million, an increase of $3.13 million, or 10.4 percent, over the FY 2008 Estimate of $30.08 million.

Science Resources Statistics Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Science Resources Statistics	**$30.04**	**$30.08**	**$33.21**	**$3.13**	**10.4%**

About SRS:

The legislative mandate for SRS as stated in the National Science Foundation Act of 1950, as amended, is "…to provide a central clearinghouse for the collection, interpretation, and analysis of data on scientific and engineering resources and to provide a source of information for policy formulation by other agencies of the Federal Government…." To meet this mandate, SRS, in its role as the federal statistical agency with responsibility to cover the S&E enterprise, provides policymakers, researchers, and other decision makers with high quality data and analysis for making informed decisions about the Nation's science, engineering, and technology enterprise. The work of SRS involves survey development, methodological and quality improvement research, data collection, analysis, information compilation, dissemination, web access and customer service to meet the statistical and analytical demands of a diverse user community, as well as preparation of the congressionally mandated *Science and Engineering Indicators* (*SEI)* and *Women, Minorities and Persons with Disabilities in Science and Engineering (WMPD)* biennial reports. The data collected by SRS serve as an important tool for SciSIP (including evaluating the impact of the ACI) and as the major component of the content of *SEI*.

The funding portfolio for SRS includes ongoing, cyclical surveys; reports and other products; and projects accomplished primarily through contracts and also a few standard grants. Funding is provided annually; SRS makes limited use of multi-year commitments. In FY 2009 SRS will:

- Continue to conduct surveys and engage in analytic activities that produce information for carrying out NSF's statutory mandate, for meeting NSF strategic goals, and for developing SEI and WMPD. SRS will also continue to undertake activities directed toward future improvements in the relevance and quality of the data it collects and the information it disseminates. Such activities will lead to ongoing quality improvements and additions to current activities in subsequent years.
- Publish data from the 2008 *Survey of Graduate Students and Postdoctorates in Science and Engineering,* which implemented the second stage of a significant redesign to improve the quality, timeliness, and accuracy of the data. Evaluations of the data improvements will be conducted and fed into further phases of the survey redesign. The FY 2009 redesign activities will be informed by user needs meetings held in FY 2008.
- Implement the results of prior methodological, analytical, and planning activities directed toward improving the quality, relevance, timeliness, and accessibility of all SRS products.
- In support of SciSIP, continue to hold numerous workshops with industry, R&D, and S&E workforce experts, data users, and innovation experts. These workshops will continue to inform and enhance the redesigns underway for the SRS surveys, analytical reports and *SEI*.

- Continue ongoing activities to improve information on the globalization of the S&E enterprise, through continued interaction with OECD, EUROSTAT, the UNESCO Institute for Statistics, and other international and national statistical agencies.
- Conduct pretests of a significantly redesigned Academic Research and Development Survey, reflecting needs of data users, as informed by numerous workshops, and to meet the needs of SciSIP and future *SEI* volumes. The redesigned survey will take into account the major changes that have occurred and are taking place in the academic sector as to how research and development are funded and conducted. The changes in the survey will reflect the complexity of how academic research is presently conducted and funded in a global knowledge economy.
- Work with the National Science Board on potential improvements and enhancements for *SEI* 2010 and 2012.

SRS Priorities for FY 2009:

- Continue to redesign the survey of R&D in the industrial and services sectors. The newly named Business Research and Development Survey will collect much needed data for the manufacturing and services sectors on the role of R&D in both the U.S. and internationally, R&D infrastructure, and the way R&D is currently conducted. The survey will collect data on crucial components needed to understand economic competitiveness. Data from the Survey will be in the 2012 *SEI*.
- Continue to develop and test strategies for gathering comprehensive data for the entire postdoc population. Postdocs are a crucial component of the science and engineering workforce yet they are rarely included in estimates of the size of that workforce. Only limited statistical data are available on the number and characteristics of postdocs and on their activities. Enhanced data about postdocs and their activities will be an important step in understanding the contributions of postdocs to the U. S. economy and competitiveness.
- Support a number of activities to determine how best to link important SRS statistical data sets with supplemental data on publications, patents, and innovation-related activities. In addition, SRS will enhance its work on harmonizing taxonomies of fields of science in order to more fully integrate its data sets both internally and with other national and international data. This activity will include support for international activities to encourage data comparability and usefulness in data collected and used by international organizations such as OECD, Eurostat and the UNESCO Institute of Statistics.

Changes from FY 2008:

Funding increase of $3.13 million to a total of $33.21 million is for work connected with SciSIP:

- $1.21 million will enable SRS to implement in FY 2009 a full-scale pilot of the Business Research and Development Survey. Data from the redesigned survey will be available for inclusion in the FY 2012 *SEI*.
- $1.17 million will enable SRS to develop a pilot data collection on postdocs based on feasibility activities undertaken in FY 2006 through FY 2008. The pilot will merge a number of developmental activities on how best to develop a sample frame for postdocs that includes in a comprehensive fashion those who do not have a research doctorate from a U.S. institution and how to obtain information about postdocs in non-academic institutions. Implementation of the pilot will take place in FY 2010.
- $640,000 will support analytical and statistical activities related to data linking, extraction, and matching to better inform and enhance the success of SciSIP.
- $110,000 will support administrative activities.

OFFICE OF CYBERINFRASTRUCTURE $220,080,000

The FY 2009 Budget Request for the Office of Cyberinfrastructure (OCI) is $220.08 million, an increase of $34.75 million, or 18.8 percent, over the FY 2008 Estimate of $185.33 million.

Office of Cyberinfrastructure Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Cyberinfrastructure	$182.42	$185.33	$220.08	$34.75	18.8%

The Office of Cyberinfrastructure supports research, development, acquisition and operation of advanced shared and connecting cyberinfrastructure that enables otherwise unrealizable advances in 21st century science and engineering research and education. OCI capitalizes on a broad range of fundamental scientific research support by the Computer and Information Science and Engineering (CISE) Directorate as well as application and social research in other directorates to create and expand the next generation of deployed cyberinfrastructure. This cyberinfrastructure is especially relevant to converting data to knowledge, understanding complexity through computational simulation and prediction, and creating more systematic, principled knowledge about the social and technical issues of powerful virtual organizations.

OCI was created in July 2005 in an organizational realignment that moved the CISE Division of Shared Cyberinfrastructure (SCI) into the Office of the Director. At the same time, a Cyberinfrastructure Committee (CIC), composed of members of NSF's senior management, was created. The CIC provides integration and strategic vision across NSF's portfolio of cyberinfrastructure activities. In FY 2007, funds were added to the OCI budget to begin the acquisition of a leadership-class high-performance computing (HPC) system optimally configured to enable *petascale* performance (computing at sustained rates on the order of 10^{15} floating point operations per second (petaflops) or working with very large datasets on the order of 10^{15} bytes (petabytes)) on important science and engineering problems.

OCI-supported cyberinfrastructure includes information technology resources and tools such as supercomputers, high-capacity mass-storage systems, system software suites and programming environments, scalable interactive visualization tools, productivity-enhancing software libraries and tools for scientific programming, large-scale data repositories and information management systems, networks of various reach and granularity, an array of software tools and services that enhance the usability and accessibility of computational, observational and experimental infrastructure, and virtual environments that make it possible for geographically distributed researchers and educators to collaborate. OCI supports socio-technical research on the way cyberinfrastructure is used and on ways of improving its effectiveness. It supports activities that develop ways of using cyberinfrastructure to augment learning as well as training in the development and use of cutting-edge cyberinfrastructure. OCI also supports the scientific and engineering professionals who create and maintain these IT-based resources and systems, and who provide the Nation's researchers and educators with essential cyberinfrastructure services. OCI makes investments that improve the cyberinfrastructure for science and engineering research, funding the deployment of cyberinfrastructure and innovative developments in cyberinfrastructure. In doing so, it both leverages and complements investments made by other agencies. For example, some of NSF's high-end computing investments take advantage of expertise at laboratories funded by the Department of Energy (DOE) and hardware and software developments funded by the Department of Defense's Defense Advanced Research Projects Agency (DARPA). In addition, OCI investments in petascale applications and tools complement those of DOE's SciDAC program, and OCI's TeraGrid infrastructure is used by researchers funded by NIH, DOE and other agencies.

OCI activities directly respond to the President's advanced networking, high-end computing and cyberinfrastructure priorities, and are key components in the Networking and Information Technology Research and Development (NITRD) priority. The technologies developed and the systems deployed by OCI facilitate discovery and innovation and bolster national competitiveness. The American Competitiveness Initiative (ACI) describes the goal of providing world-leading, high-end computing capability, coupled with advanced networking, to enable scientific advancement through modeling and simulation at unprecedented scale and complexity across a broad range of scientific and engineering disciplines. OCI investments in high-performance computing for research and education, the TeraGrid infrastructure, and international network connections directly contribute to this goal.

OCI will participate in the NSF-wide Cyber-enabled Discovery and Innovation (CDI) investment through the development, deployment, and use of enabling cyberinfrastructure, made in collaboration with NSF's research directorates.

The FY 2008 appropriation will reduce funding available for new activities presented in last year's budget request. Among these are: a $7.50 million reduction in the funds available for the acquisition of a new high-performance computing system; a roughly 40 percent reduction in investment for a new activity designed to respond to the growing need for innovative approaches to the long-term curation of digital data; a 40 percent reduction in OCI's ability to invest in the new Cyber-enabled Discovery and Innovation program; and the deferral to FY 2009 of the start of a planned new activity aimed at the integration of research and education through cyberinfrastructure.

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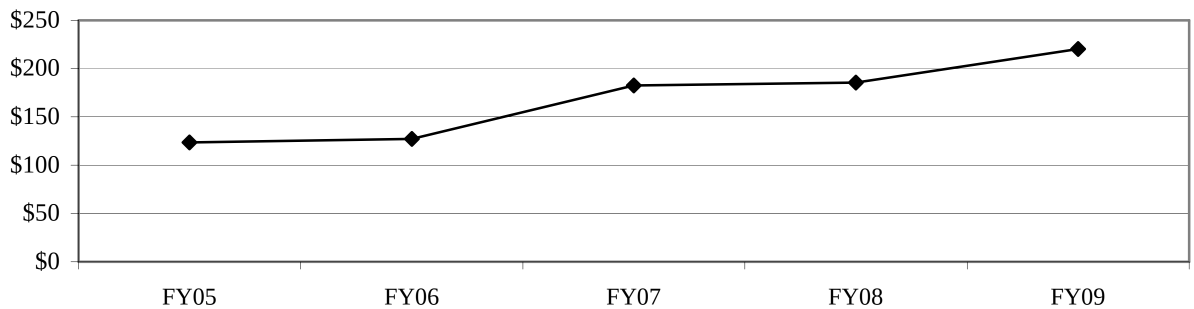
OCI Subactivity Funding
(Dollars in Millions)



RELEVANCE

What happens to space-time when two black holes collide? What impact does species gene flow have on an ecological community? What are the key factors that drive climate change? What are the mechanisms operating within cellular signaling pathways? How do we design nano-materials with useful electrical, optical, or mechanical properties? How does major technological change affect human behavior and structure complex social relationships? By combining the analysis of the huge datasets that will be generated by the next generation of astronomical instruments with advanced cosmological modeling, can we determine the distribution and effects of dark matter in the cosmos?

Advances in computing and related information technology are providing us with the ability to answer these and other questions that were previously beyond our reach, either directly through computation or as a result of the new modes of collaboration and analysis enabled by digital technology. The ability of modern observing technology to produce unprecedented quantities of empirical data, in fields of research such as particle physics, astronomy, and the environmental sciences, drives the development of new ways of managing, analyzing, visualizing, and representing data. The availability of data in digital form prompts the development of new approaches to querying and melding diverse datasets that permit interdisciplinary groups to collectively address much more complex research questions.

The Office of Cyberinfrastructure's investments are guided by NSF's *Cyberinfrastructure Vision for 21st Century Discovery* (www.nsf.gov/dir/index.jsp?org=OCI), a comprehensive cyberinfrastructure strategic plan for the Foundation; by the American Competitiveness Initiative, by the America COMPETES Act, and by the opportunities identified by the academic and industrial research community through workshops and white-papers. It also responds to OSTP's and OMB's memo of August 14, 2007, on R&D budget priorities which stated that, "High-end computing should be increasingly used to support research for transformational solutions to complex problems in energy, climate and weather, human health, new materials and national security."

OCI supports the development and deployment of cyberinfrastructure that is shared by all scientific and engineering disciplines, making possible potentially transformative basic research in areas such as nanotechnology, physics, chemistry, materials science, and engineering, as called for in the ACI. It also promotes interoperability between components of cyberinfrastructure both here in the U.S. and abroad. About two-thirds of NSF's investments in cyberinfrastructure are made by the directorates and offices responsible for fundamental domain specific research and education in science and engineering, with the remaining one-third provided by OCI. Through coordinated planning and investments facilitated by NSF's Cyberinfrastructure Council, OCI provides economies of both scale and scope, ensuring that NSF's cyberinfrastructure portfolio delivers the highest returns on the Nation's investment.

Summary of Major Changes in Office-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, OCI…..………………………..……………………………………………$185.33

Discovery +$12.75

Software and Services for Complex Science and Engineering (+$13.23 million).

OCI will extend its support of this area for the development and provision of software and services that facilitate complex science and engineering research (+$6.98 million). These include: innovative approaches to the management of data collections; software and practices that enhance the semantic interoperability of data and tools; robust middleware that supports distributed applications, distributed collaboration, interactive remote observation, and the tele-operation of instruments and experimental facilities; cybersecurity test-beds; as well as advanced data analysis and multi-modal visualization tools. Advances in the analysis and management of data from observations, experiments, and computational models are critical to advancing ACI goals in data-intensive areas such as nanotechnology, materials science, weather and climate prediction, and the prediction of hazards from events such as earthquakes and hurricanes. OCI will continue to provide opportunities to researchers who wish to exploit new ideas emerging from computer science and elsewhere and to explore whether these have the potential to be the next revolutionary strategic technologies in cyberinfrastructure. As such technologies mature, they will contribute to strengthening the capabilities of computing systems and advanced networks as highlighted in the ACI, and to the provision of new tools for basic research.

OCI will increase its investment in the development and provision of software and services that facilitate complex science and engineering research through the Cyber-enabled Discovery and Innovation initiative (+$6.25 million). (Addition OCI investments in CDI are described under Research Infrastructure.) Additional areas of emphasis include: the use of *in situ* computation in sensor networks; virtual organizations that are built around specific complex science and engineering research foci and that leverage other NSF investments such as those in the TeraGrid, in observing systems, and in specialized experimental equipment; research aimed at improving the effectiveness of collaborative digital environments; novel modeling methodologies that include the flow of uncertainty in predictive simulations; research on ways of programming novel computational architectures; and the development of more robust approaches to fault-tolerant computing in science and engineering.

Accelerating Discovery in Science and Engineering through Petascale Simulations and Analysis (PetaApps) (-$6.84 million).

After successfully stimulating the development of petascale application software, the pace of new investments in such software will be reduced in FY 2009. There remains a need for additional software for petascale computing (e.g. new scalable algorithms, new programming models, better debugging techniques, tools for analyzing extremely large datasets, and multi-scale, multi-physics models). These are being partially addressed in an ad hoc fashion through various NSF programs. A further PetaApps solicitation is being discussed and it is likely that this activity will be resumed when sufficient funds are available.

Cyber Services (+$6.36 million).

Some OCI activities consist of the provision of cyber-services and access to cyber-resources; others are explorations of new directions in technology development; and some involve the development or deployment of cyberinfrastructure prototypes. In the first two years of OCI's existence, most of these activities were classified as infrastructure. However, based on the experience of the last two years, it seems more appropriate to include those activities associated with research, development and prototyping of new cyberinfrastructure within the Discovery strategic outcome goal. These are activities in which cyberinfrastructure is the main object of research.

<u>Learning</u> -$6.00

Integration of research and education through cyberinfrastructure (+$4.0 million).

In collaboration with other directorates and offices across the Foundation, OCI will support the development of innovative technologies that will facilitate the integration of research and education, creative explorations and demonstrations of the use of these and other cyberinfrastructure to integrate research with education, and research on how educators and students interact with cyberinfrastructure. One aim of this support is to connect students and educators with the types of science and engineering that are themselves being facilitated by cyberinfrastructure, and that are difficult or ineffective to reproduce in a school laboratory or informal education setting using traditional methods.

Cyberinfrastructure Training, Education, Advancement and Mentoring (-$10.0 million).

This activity, having successfully achieved its objective of stimulating new collaborations between domain scientists and cyberinfrastructure experts and encouraging them to initiate learning and workforce development activities that complement ongoing NSF investment in cyberinfrastructure, has reached the end of its planned lifetime.

<u>Research Infrastructure</u> +$27.30

High Performance Computing: Acquisition, Operations and Maintenance (+$24.42 million).

Increased funding is for the acquisition, operations, and maintenance of high-performance computing (HPC) systems and for the national open science and engineering research community. These leading-edge computational resources, together with advanced networking capabilities, serve to maintain NSF's national supercomputing grid, the TeraGrid, as the world's leading high-end computing environment for open research. They are used in innovative research in areas ranging from biology, materials science and physics to engineering and social science. This activity is directly responsive to the ACI's goal of providing a "world-leading high-end computing capability (at the petascale) and capacity, coupled with advanced networking, to enable scientific advancement through modeling and simulation at unprecedented scale and complexity across a broad range of scientific disciplines." OCI's investments in this area are coordinated with those of other federal agencies, primarily through the High-End Computing Inter-agency Working Group.

Digital preservation and analysis (+$3.0 million).

OCI will increase its investments in DataNet, an activity launched in FY08. These investments are aimed at stimulating exemplar data research infrastructure organizations. By integrating library and archival sciences, cyberinfrastructure, computer and information sciences, and broad science expertise, these investments will develop a prototype infrastructure for providing reliable digital preservation and analysis capabilities for science and/or engineering data.

Cyber-enabled Discovery and Innovation initiative (+$6.24 million).

OCI will support the development and deployment of cybertools for pattern recognition, feature extraction, and feature tracking in streaming data, for mining, analyzing, and representing very large, multi-variate spatiotemporal datasets, and for model generation and validation through the Cyber-enabled Discovery and Innovation investment. (See also Discovery.)

Cyber Services (-$6.36 million).

See above under Discovery.

<u>Stewardship</u> +$0.70

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$34.75

FY 2009 Request, OCI…………………………………………………………………..………. $220.08

QUALITY

OCI maximizes the quality of the projects it supports through the use of a competitive, merit-based review process. The percent of funds that were allocated to projects that undergo external merit review was 99 percent in FY 2007, the last year for which complete data exist.

To ensure the highest quality in processing and recommending proposals for awards, OCI convenes a Committee of Visitors, composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. The next OCI Committee of Visitors is scheduled for FY 2008. The OCI Committee of Visitors (COV) is charged with assuring that the programs administered in OCI meet NSF's high standards of program management and to ensure openness to the research and education community served by the Foundation and that attempts are made to improve performance. The COV will focus on two specific areas, in the context of OCI's four focus areas of High Performance Computing, Data, Virtual Organizations, and Learning and Workforce Development: (1) assessments of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions; and (2) comments on how the outputs and outcomes generated by awardees have contributed to the attainment of NSF's mission and strategic outcome goals. While all OCI awards will be under consideration, this particular OCI COV will pay particular attention to the OCI high-performance computing portfolio due to its importance to the science and engineering community.

OCI's activities are guided by the document, *Cyberinfrastructure Vision for 21st Century Discovery*, developed by NSF based on input from the research and education community, and by national priorities highlighted in the American Competitiveness Initiative, the America Competes Act, and the August 2007 memo on R&D priorities from OMB and OSTP. In partnership with NSF's directorates and offices, OCI receives advice from the Advisory Committee for Cyberinfrastructure (ACCI) on such issues as: the mission, programs, and goals that can best serve the science and engineering community; how OCI can promote quality graduate and undergraduate education in the computational sciences and engineering; and priority investment areas in cyberinfrastructure. The ACCI meets twice a year. Members from both academe and industry represent a cross section of the science and engineering field, with representatives from many different disciplines. The ACCI includes a balanced representation of women, underrepresented minorities, and individuals from a range of geographic regions and institutions. Internally, mechanisms to maintain integration across NSF's cyberinfrastructure activities include the executive-level Cyberinfrastructure Council, which includes the Director, the Assistant Directors and the Office Heads, and the Cyberinfrastructure Coordinating Committee composed of program officers representing the directorates and offices and chaired by the Office Head for OCI.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals highlighted in the FY 2006-2011 Strategic Plan. These goals were designed as a mechanism to better enable assessment of program performance and to facilitate budget and performance integration.

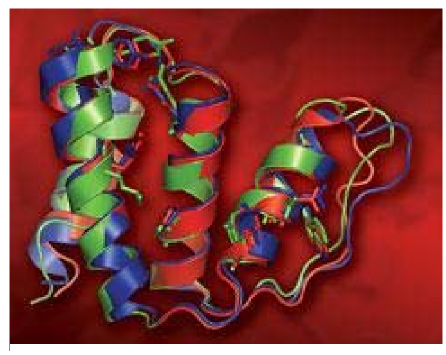
Office of Cyberinfrastructure
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Discovery	$3.99	$14.75	$27.50	$12.75	86.4%
Learning	0.57	10.10	4.10	-6.00	-59.4%
Research Infrastructure	176.28	158.43	185.73	27.30	17.2%
Stewardship	1.58	2.05	2.75	0.70	34.1%
Total, OCI	$182.42	$185.33	$220.08	$34.75	18.8%

Totals may not add due to rounding.

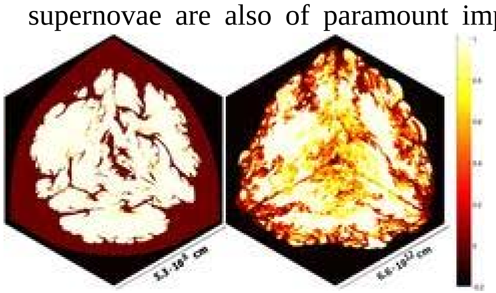
Recent Research Highlights

► **Speeding Simulations for Drug Design:** Proteins are the building blocks of the body, and biologists have learned that the myriad ways they function--from fighting off infection and building new bones to storing a memory--depend on the precise details of their 3-D shapes. But determining the shapes of proteins has been a slow and exacting process. To speed up this important science, researchers at the NSF-funded San Diego Supercomputer Center helped biologists from the University of Washington begin to harness the power of massive supercomputers. After working to adapt the computer code, they used one of TeraGrid's supercomputers to compute a protein structure in just three hours, something that normally takes weeks. By dramatically accelerating scientific research, modern supercomputers are opening the door to medical advances such as rational drug design.



Three-dimensional structure of a protein, one of the building blocks of life. *Credit: R.C. Walker, SDSC/UCSD and S. Raman, University of Washington.*

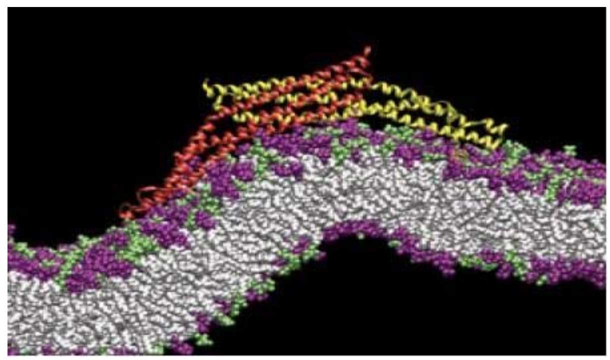
► **Long Time Modeling of Type Ia Supernovae:** Among the brightest objects in the sky, Type Ia supernovae are also of paramount importance in cosmology, serving as "standard candles" that help scientists accurately mark off distance across the universe. To harness new precision cosmology to better calibrate these standard candles, scientists at the ASC Flash Center at the University of Chicago have used their enhanced TeraGrid simulation code to conduct the longest, self-consistent, 3-D, numerical simulation of a Type 1a supernova explosion ever performed. The computations extended from supernova ignition through the active explosion phase, following the evolution for 11 days and revealing a longer-than-expected evolution with distinct stages. Such simulations are an important complement to the observations. The simulations' capability allows researchers to make meaningful comparisons of their theoretical and numerical models with observations.



Cross-sections through one eighth of a star's volume, showing the distribution of material that has undergone nuclear fusion (from white – fully burned – to dark red – unburned) at two different times (left - two seconds after ignition; right - after 77 minutes). *Credit: Dr. Alexei Poludnenko, ASC Flash Center, Dept. of Astronomy & Astrophysics, University of Chicago.*

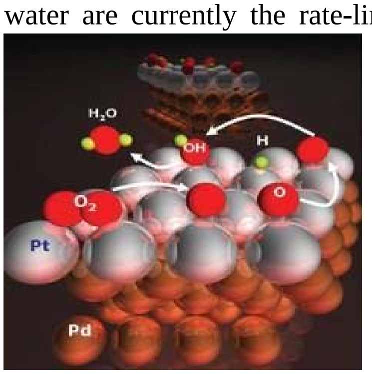
► **Securing Urban Water Supplies:** Urban water distribution systems cover hundreds of square miles and include thousands of miles of pipe. But in most cases, drinking water is largely unmonitored after it leaves the treatment plant, making it possible to intentionally contaminate a water supply using simple equipment. With this in mind, and to help improve water quality, researchers have developed new methods of locating the source of contaminants and testing approaches to limiting their impact. Working with data from sensor networks in large metropolitan areas, they used evolutionary computation to search through the large number of possible solutions until the contaminant distribution in the computational model matched the real-world sensor data. This procedure used hundreds of processors simultaneously on TeraGrid systems. The researchers expect these techniques will prove useful to cities that are installing networks with hundreds of thousands of sensors. Current simulations already are showing officials how to cope with problem situations. Extensions of these techniques may help assess the vulnerabilities of urban water systems to deliberate contamination and evaluate strategies for detection and mitigation.

► **How Proteins Induce Curvature in a Cell Membrane:** Using a range of TeraGrid resources, researchers at the University of Utah modeled and observed for the first time how proteins induce curvature in a cell membrane. Their findings provide new details about an essential cellular process involving BAR. BAR domains are a family of banana-shaped proteins that bind to cellular membrane as it curves--a process by which cells absorb material from outside. The researchers used TeraGrid systems to explore how long a stretch of membrane they needed for curvature to occur. Their final simulations included the protein interacting with a 50-nanometer length of membrane--probably the longest patch of membrane ever simulated. Their results confirm experimental findings and show that the orientation of the BAR domain as it attaches to the membrane determines the degree of curvature.



Close-up of the midsection of a 50-nanometer length of membrane after 27 nanoseconds of simulation showing the curvature produced by the BAR domain (orange and yellow helices) molded to the membrane surface. *Credit: Gregory Voth, University of Utah.*

► **Better Fuel Cells:** Splitting oxygen molecules into oxygen atoms and the subsequent formation of water are currently the rate-limiting step in getting energy from fuel cells, the reaction that restricts overall power production. Researchers at the University of Wisconsin and Brookhaven National Lab are exploring the oxygen reduction reaction, and the catalyst that provokes it, by using the TeraGrid resources at the National Center for Supercomputing Applications. They found that palladium with a platinum monolayer offered the best overall performance characteristics, improving the overall efficiency of the oxygen reduction reaction by 33 percent.



Possible reaction pathway for the oxygen reduction reaction on a catalytic surface. *Credit: Manos Mavrikakis, UW-Madison.*

► **The Roots of Entrepreneurial Success**: Economists have long debated the factors leading to entrepreneurial success: are entrepreneurs uniquely optimistic and more willing to assume risks, or are environmental factors, such as bankruptcy laws and the availability of credit, more significant? Economics researchers at the University of Illinois at Urbana-Champaign have developed a model that considers individual differences in willingness to bear risk and optimism. The model can also evaluate the effect of bankruptcy rules on small firms. Researchers applied the model to data from the Survey of Small Business Finance. Using TeraGrid computing resources they were able to quickly determine if the behavioral predictions of a particular theory could be reconciled with economic data. This necessitated computing many integrations of an economic model, varying a large number of policy parameters. Their results indicate that the environment in which businesses operate influences success more than personal characteristics, and that entrepreneurs are not excessive risk-takers.

Other Performance Indicators

The table below shows an estimate of the number of people benefiting from OCI funding based on the types and number of awards. However, OCI investments directly impact a much larger number of researchers and educators within the U.S. and around the world who use OCI-supported cyberinfrastructure facilities, resources, and tools.

Number of People Involved in OCI Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	206	245	360
Other Professionals	577	515	525
Postdoctorates	16	22	25
Graduate Students	114	150	190
Undergraduate Students	51	70	95
Total Number of People	964	1,002	1,195

OCI Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	70	71	72
Funding Rate	23%	23%	23%
Statistics for Research Grants:			
Number of Research Grants	43	50	55
Funding Rate	19%	18%	18%
Median Annualized Award Size	$450,000	$400,000	$400,000
Average Annualized Award Size	$511,682	$440,000	$440,000
Average Award Duration, in years	2.2	2.5	2.5

OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING $47,440,000

The FY 2009 Budget Request for the Office of International Science and Engineering (OISE) is $47.44 million, an increase of $6.10 million, or 14.8 percent, over the FY 2008 Estimate of $41.34 million.

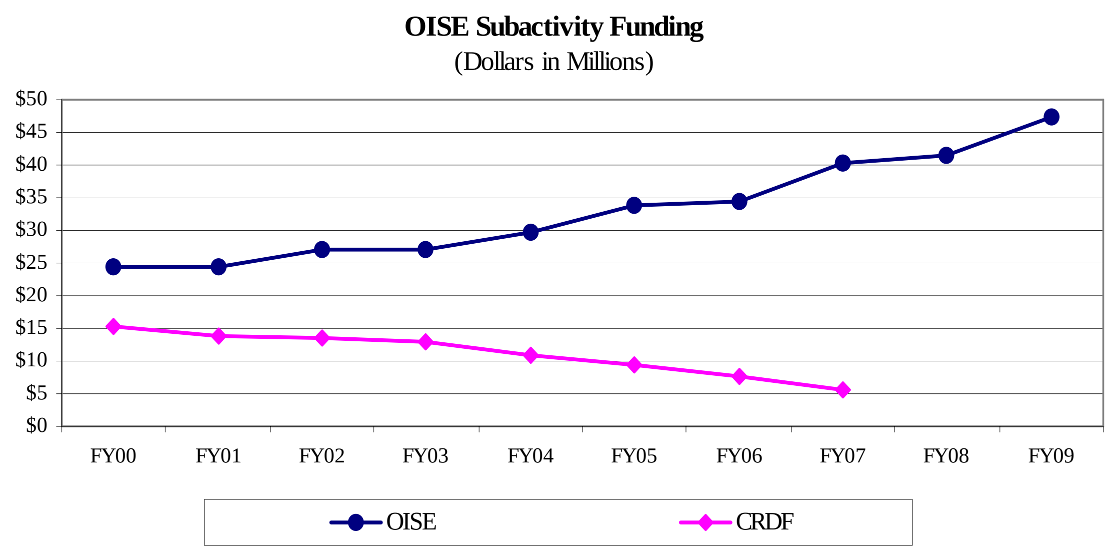
Office of International Science and Engineering Funding

(Dollars in Millions)

	FY 2007 Actual[1]	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
OISE	$40.36	$41.34	$47.44	$6.10	14.8%

[1] FY 2007 Actual excludes $5.46 million in funds provided by the U.S. Department of State for an award to the US Civilian Research Foundation.

The Office of International Science and Engineering serves as the focal point, both inside and outside NSF, for international science and engineering activities. OISE promotes the development of an integrated, Foundation-wide international strategy, and manages international programs that are innovative, catalytic, and responsive to a broad range of NSF and national interests. Recognizing that scientific discovery is a global enterprise, OISE supports U.S. scientists and engineers engaged in international research and education activities in all NSF-supported disciplines involving any region of the world.



The bottom line shows additional funds provided by the U.S. Department of State for an award to the U.S. Civilian Research and Development Foundation (CRDF) in FY 2000 ($15.40 million), FY 2001 ($13.75 million), FY 2002 ($13.66 million), FY 2003 ($12.83 million), FY 2004 ($10.99 million), FY 2005 ($9.42 million), FY 2006 ($7.73 million), and FY 2007 ($5.46 million).

RELEVANCE

Science and engineering are international enterprises critical to American competitiveness and security. Bold exploration at the frontiers of science and engineering increasingly requires international partnerships. NSF – as the Nation's principal source of support to U.S. universities for fundamental science, mathematics, and engineering research and education – plays a unique role in leading the worldwide efforts of the U.S. science, engineering, and education communities.

OISE programs and activities are designed to complement and enhance the Foundation's broad research and education portfolio and to overcome barriers involved in international collaboration. America's next generation of scientists and engineers must be able to work effectively in the global arena and marketplace. OISE supports programs that enable students and researchers to experience and engage in international research and educational activities across such areas as cyberinfrastructure, complex biological systems, natural hazards prediction and mitigation, nanotechnology, water resources, and math and science education. OISE carries out its functions by working closely with the other NSF directorates and offices as well as through its own programs. Additionally, OISE manages NSF's offices in Beijing, Paris, and Tokyo that report on and analyze in-country and regional science and technology developments and policies, promote greater collaboration between U.S. and foreign scientists and engineers, liaise with foreign counterpart agencies and research institutes, and facilitate coordination and implementation of NSF research and education programs.

Summary of Major Changes in Office-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, OISE... $41.34

Discovery +$5.18

Disciplinary and Interdisciplinary Research (+$5.18 million).

In FY 2005, OISE launched a pilot program: *Partnerships for International Research and Education (PIRE).* This program funds innovative, international collaborative research projects that link U.S. institutions and researchers at all career levels with premier international collaborators to work at the most promising frontiers of new knowledge. In FY 2007, OISE held a second PIRE competition. More than 500 preliminary proposals were submitted, the largest response ever for an OISE program. Given the increasing importance of the U.S. scientific and engineering community having access to the best researchers and facilities around the world, OISE will build on the first two PIRE competitions by supporting a third solicitation in FY 2009. OISE will invest $3.0 million in new funds in the FY 2009 PIRE competition resulting in a program total of $15.0 million. For Cyber-enabled Discovery and Innovation (CDI), a $500,000 investment is proposed for FY 2009. Working in partnership with the Directorate for Computer and Information Science and Engineering (CISE), OISE's objective is to identify and link communities of researchers across international boundaries to facilitate communication and collaboration between the United States and the international scientific community. The remaining $1.68 million in new funds will be used to augment other international collaborative research supported by OISE as well as international planning visits and workshops program.

Learning +$0.65

OISE makes significant investments in developing and strengthening the current and future pool of scientists and engineers. In FY 2009, OISE will reallocate funding to augment OISE-managed programs in order to provide international experiences for students and researchers.

International Research Experiences for Students (+$500,000).
This funding, coupled with other funding that OISE will make available, will expand OISE's investment by $500,000 to $3.15 million, thus enabling OISE to support a higher percentage of highly-rated projects. Awareness of this program has grown, and additional funding will support approximately 60 more U.S. undergraduate and graduate students (increasing the total to approximately 360 per year) by providing early-career growth opportunities through international cooperative research training and networking, and mentoring. This program was one of three new programs introduced by OISE in 2004 and will undergo review by the 2008 Committee of Visitors.

International Research Fellowship Program (+$400,000).
In FY 2009, an increase of $400,000 will bring the program total to $4.50 million. The additional funding will support 2 to 3 additional postdoctoral fellows, which will result in 40+ international postdoctoral fellows supported under this program. The Committee of Visitors in 2005 recommended that OISE allocate additional resources to increase the funding rate of this highly subscribed and successful program. In response, OISE has incrementally increased program support each year since 2005.

Research Experiences for Teachers Program (-$250,000).
As a primary focus of OISE programs is providing international research experiences for students, OISE will reduce the support for the Research Experiences for Teachers Program from $500,000 to $250,000 in FY2009.

Stewardship +$0.27

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$6.10

FY 2009 Request, OISE.. $47.44

OISE Priorities for FY 2009

During the past several years, OISE has implemented changes to define more clearly its programmatic priorities, to better link OISE to overall NSF goals, broaden the applicant pool and to move toward larger, more innovative awards. OISE's key programmatic themes for FY 2009 are:

- Promoting research excellence through international collaboration; and
- Providing U.S. students, postdoctoral researchers, and junior faculty with international research and education experiences.

These themes reflect the fact that the process of discovery and the scientific/engineering workforce are increasingly global. The United States needs to engage actively in the global research community through collaborative research and must ensure that its young scientists and engineers are capable of operating in an international research environment and a global market.

The OISE portfolio, which is primarily made up of awards to U.S. researchers and institutions, reflects both programs managed by OISE and investments made in partnership with other NSF directorates and offices. Approximately 54 percent of OISE's portfolio is available for all new awards each year while approximately 39 percent of OISE's portfolio is available for new research grants. The remainder is used primarily to fund awards made in previous years.

Specific emphases in FY 2009 are to:

- Continue major investments to promote research excellence through international collaboration. OISE will hold a third competition of the **Partnerships for International Research and Education** program. OISE will partner with other NSF research directorates and offices and foreign research organizations to catalyze research in NSF's **Cyber-enabled Discovery and Innovation** program. Other OISE investments to advance research excellence include: supporting workshops and planning visits to explore and develop collaborations; and co-funding and supplemental funding to highly competitive NSF awards that involve international work.

- Support **international research and education experiences** for U.S. early-career researchers, students, and teachers through OISE-managed and other NSF programs. This includes: the International Research Experiences for Students; the East Asia and Pacific Summer Institutes for U.S. Graduate Students; the Pan-American Advanced Studies Institute; the International Research Fellowship Program for postdoctoral researchers; funding for undergraduate and graduate students, postdoctoral researchers, and early-career faculty to engage in international collaborative activities; and opportunities for K-12 students and teachers.

- Promote increases in America's science and engineering talent pool by **broadening participation** of women and underrepresented groups in NSF-supported international research and education activities.

- Provide U.S. Government support to key **multilateral organizations**, thereby enabling U.S. scientists to participate in these global efforts. Multilateral groups expected to be funded include the Human Frontier Science Program, Global Biodiversity Information Facility, International Council for Science, International Neuroinformatics Coordinating Facility, and International Institute for Applied Systems Analysis.

- Continue efforts to expand networks between the U.S. research community and those in **developing countries** as well as to identify new opportunities for collaboration.

NSF-WIDE INVESTMENTS

In FY 2009, OISE will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

These investments are based on a highly-focused and strategic framework that simultaneously strengthens core research, enhances interdisciplinary collaborations, promotes the integration of research and education, and collectively benefits the U.S. economy and citizenry. Within OISE, funding will support/contribute to ensuring that U.S. research and education objectives in these important areas benefit from international collaboration. OISE investments focus on innovative, catalytic activities, with the understanding that U.S. researchers with established international collaborations will seek funding directly from other NSF directorates/offices. OISE investments in these NSF-wide investment areas support planning visits, workshops, principal-investigator-led collaborative research, international research experiences for U.S. students and postdoctoral researchers, and other catalytic activities.

Office of International Science and Engineering NSF-wide Investments

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Biocomplexity in the Environment	$0.14	-	-	-	N/A
Cyber-enabled Discovery and Innovation	-	0.50	0.50	-	-
Cyberinfrastructure	1.30	0.75	0.75	-	-
Human and Social Dynamics	0.47	0.50	-	-0.50	-100.0%
International Polar Year	0.54	0.40	-	-0.40	-100.0%

Biocomplexity in the Environment and **Human and Social Dynamics:** With the conclusion of these priority areas in FY 2007 or FY 2008 (as noted in the table above), key components of these investments will be retained for core programs.

Cyber-enabled Discovery and Innovation: A $500,000 investment for CDI is proposed for FY 2009. Working in partnership with CISE, OISE's objective is to identify and link communities of researchers across international boundaries to facilitate communication and collaboration between the United States and the international scientific community.

Cyberinfrastructure: OISE will maintain its funding level of $750,000 for Cyberinfrastructure. OISE will coordinate with NSF directorates and offices to ensure that the international dimensions of cyberinfrastructure are highlighted and developed.

International Polar Year: With the conclusion of IPY in March 2009, key components of this investment will be retained for core programs.

QUALITY

OISE maximizes the quality of research and education activities it supports through the use of a competitive, merit-based review process. Within the existing portfolio, the percentage of funds allocated to projects that undergo merit review was 69 percent in FY 2007 and is estimated at 65 percent in FY 2008 and 70 percent in FY 2009. The majority of projects that did not undergo external review were supplements that added an international dimension to projects already merit reviewed and funded by NSF disciplinary programs.

To ensure the highest quality in processing and recommending proposals for awards, a Committee of Visitors composed of external experts reviewed OISE in FY 2005 and affirmed the high quality of funded projects, of OISE's program portfolio management, and of OISE's unique enabling role within NSF regarding international activities and issues. The Committee of Visitors' 2005 report stated that the new OISE program, Partnerships for International Research and Education (PIRE), was a bold new program.

The Committee of Visitors meeting planned for Spring of 2008 will, *inter alia*, review the results of the first two PIRE competitions and will make recommendations for future PIRE competitions.

Additionally, the Advisory Committee for International Science and Engineering, composed of members representing the U.S. research and education community across disciplines, was established in June 2005. The committee meets twice a year and advises OISE on its programs and the integration of international activities across the Foundation. The committee includes a balanced representation of women, members of under-represented minorities, and geographic regions.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Office of International Science and Engineering
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Discovery	$27.45	$26.39	$31.57	$5.18	19.6%
Learning	11.95	12.60	13.25	0.65	5.2%
Research Infrastructure	-	-	-	-	N/A
Stewardship	0.96	2.35	2.62	0.27	11.5%
Total, OISE	$40.36	$41.34	$47.44	$6.10	14.8%

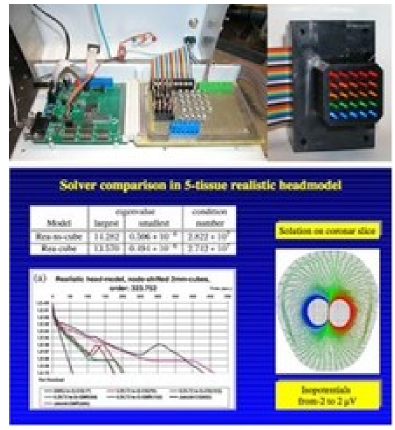
Totals may not add due to rounding.

Recent Research Highlights

Large tanker vessels pose a risk in the Bosphorus Strait due to the narrowness of the waterway and the high volume of ship traffic. *Credit: Tayfur Altiok.*

► **Reducing Accident Risks in Narrow Waterways:** A team at Rutgers University has developed a computer-based risk model that can improve vessel traffic management in narrow waterway passages while also mitigating risks to the local environment and population. The Rutgers team collaborated with Bosphorus University in Istanbul to develop a high-fidelity simulation model that replicates maritime operations in the Istanbul Strait. The Strait is among the world's busiest and most accident-prone waterways. The risk model computes the probabilities of potential accidents, instigator probabilities, accident probabilities, and consequences. The mathematical risk model is superimposed onto a simulation model and then analyzed in order to find ways to mitigate the risks involved. U.S. waterway managers recognize that these important modeling/risk insights can be applied with significant benefit to narrow waterway passages in the U.S.

► **U.S. and Austria Collaborate to Solve Computational Problems in Science and Mathematics:** Computer science researchers at the University of Kentucky, Johannes Kepler University of Linz, Austria, and the Karl-Franzens University of Graz, Austria are collaborating to develop tools to hasten from six to 12 months to a few days the identification of algorithms capable of solving industrial-quality computations. New research developments in algebraic multigrid have enabled the U.S. and Austrian teams to produce an open-source, community resource to develop an expert system for more swiftly choosing algorithms capable of solving complex, industrial-quality computational problems. Potential applications of the work include producing useful software and new methods for determining how injected drugs spread throughout the body and how they might be directed to specific locations. The participation of students is crucial to the success of the research.



An example of computational modeling of head tissues. *Credit: Craig Douglas.*

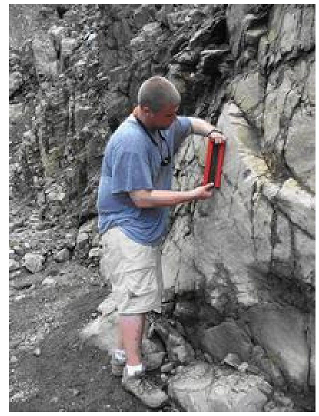
Shown here is Mr. Andrew Marchesseault, in the clean room facility at the Technical University of Braunschweig, inspecting visually a micro-sensor that he fabricated in the laboratory. Mr. Marchesseault is a dual-degree master's student at the University of Rhode Island. *Credit: Andrew Marchesseault.*

► **U.S. – German Team Investigating Faster, More Accurate Method for Detecting Viruses Using Mass Measurement:** U.S. and German researchers have made discoveries that can speed up and improve the sensitivity of detection of disease-causing viruses using rapid mass measurements. Currently, the improved production speed and quality of manufactured viruses is a major component in engineering research. The quality of viruses is important in both vaccine productions as well as for gene therapy, and speed can be a major factor during flu seasons since viruses mutate very quickly and time between vaccine discovery and distribution is limited. The researchers are part of a collaboration funded through the Partnerships for International Research and Education program supported by NSF's Office of International Science and Engineering and the Division of Chemical, Bioengineering, Environmental, and Transport Systems.

► **Graduate Students Study Links Between African and U. S. Weather Systems:** Graduate students worked with American and international researchers on a project called the African Monsoon Multidisciplinary Analysis. The NSF-funded graduate research team, based in the West African region, focused on studying storms and weather systems at their source. In Cape Verde, they investigated easterly waves, developing tropical cyclones, Saharan dust outbreaks, convection, and cloud microphysics. In Senegal, they used advanced equipment to track precipitation, predict rainfall, and measure air pressure. Their findings contributed to the understanding of the effects of African weather systems on the U.S., particularly how land storms become ocean storms and then make their way west to U.S. and Caribbean waters.

Graduate students study African storms onboard a DC-8 airplane to understand links to U.S. storms. *Credit: Dr. Gregory Jenkins, Howard University.*

► **Reconnaissance Survey of a Major Landslide in the Philippines:** Following a major landslide – one of the largest recorded in recent history – in Leyte, Philippines in February 2006, NSF-supported researchers at Virginia Polytechnic Institute and Iowa State University visited the area to immediately collect evidence and data of possible causes before debris was removed and rebuilding of the city began. The U.S. researchers, who collaborated with Philippine counterparts, used their extensive experience in geotechnical engineering and post-failure investigation to study the cut made by the landslide on the surface of the mountain. The study resulted in a better understanding of the geological effects of severe weather due to global warming and established long-term collaboration on geohazards research.



Student performing field geological mapping at the foot of the scarp. *Credit: Dr. Marte Gutierrez.*

Other Performance Indicators

Number of People Involved in OISE Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	1,023	1,035	1,210
Other Professionals	29	33	40
Postdoctorates	647	660	765
Graduate Students	1,412	1,430	1,670
Undergraduate Students	1,043	1,070	1,235
Total Number of People	4,154	4,228	4,920

The funding rate for competitive awards in FY 2009 is estimated to remain relatively unchanged. In years when PIRE competitions are held (FY 2005, 2007, 2009), the average award size increases significantly. This is due to the size and number of the average PIRE award ($500,000 per year multiplied by 20 awards in FY 2007) in comparison to the average non-PIRE award ($50,000 per year) managed by OISE.

OISE Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	355	350	370
Funding Rate	46%	40%	40%
Statistics for Research Grants:			
Number of Research Grants	82	90	100
Funding Rate	22%	20%	20%
Median Annualized Award Size	$46,800	$30,000	$50,000
Average Annualized Award Size	$156,673	$50,000	$175,000
Average Award Duration, in years	2.4	2.6	3.0

NOTE: The spike in the average annualized award size in FY 2007 and 2009 is due to the PIRE competition for those years.

OFFICE OF POLAR PROGRAMS $490,970,000

The FY 2009 Budget Request for the Office of Polar Programs (OPP) is $490.97 million, an increase of $48.43 million, or 10.9 percent, over the FY 2008 Estimate of $442.54 million.

Office of Polar Programs Funding

(Dollars in Millions)

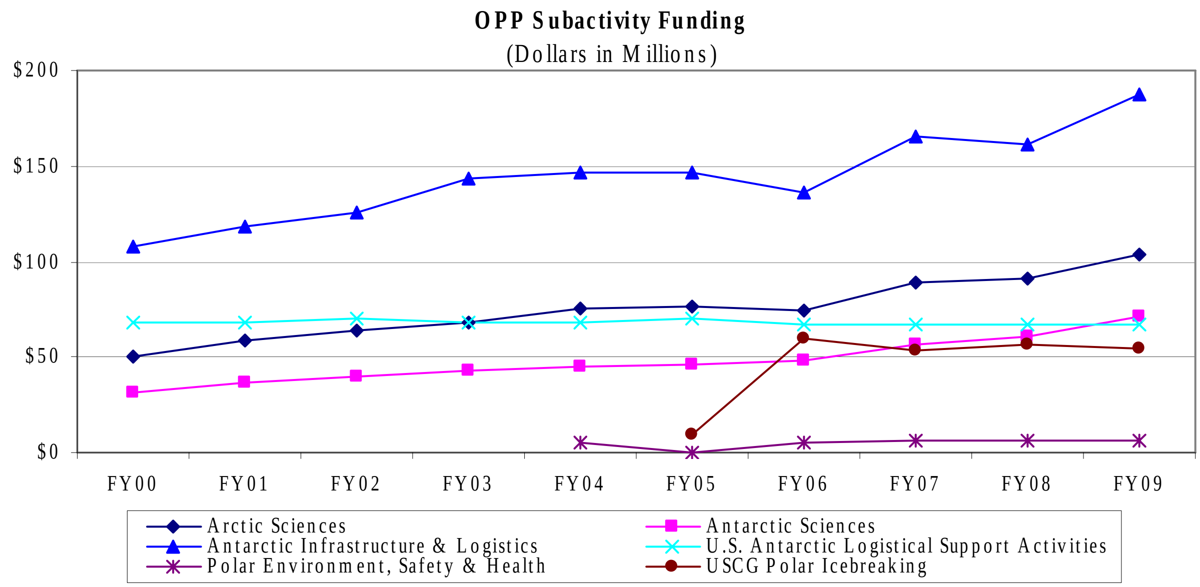
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Arctic Sciences (ARC)	$89.27	$90.85	$103.97	$13.12	14.4%
Antarctic Sciences (ANT)	56.65	60.35	71.24	10.89	18.0%
Antarctic Infrastructure & Logistics (AIL)	233.76	228.36	255.02	26.66	11.7%
U.S. Antarctic Logistical Support Activities	*67.52*	*67.52*	*67.52*	-	-
Polar Environment, Safety & Health (PESH)	5.79	5.98	6.74	0.76	12.7%
USCG PolarIcebreaking[1/]	52.96	57.00	54.00	-3.00	-5.3%
Total, OPP	$438.43	$442.54	$490.97	$48.43	10.9%

Totals may not add due to rounding.

[1/] Represents all funding to U.S. Coast Guard. In FY 2007, NSF chartered the icebreaker *Oden* as a back-up to the USCG's *Polar Sea*. The *Oden* will again be chartered for FY 2008 and FY 2009. Funds may become available from this line to contribute to defraying the costs of back-up icebreakers.

The Office of Polar Programs supports most of the research in polar regions funded by NSF. The Arctic and Antarctic are premier natural laboratories whose extreme environments and geographically unique settings enable research on phenomena and processes not feasible elsewhere. For example, the cold, dry environment and high altitude at the South Pole make it the world's best location for key astrophysics measurements. Polar research provides insights into earth systems – the atmosphere, oceans and solid earth – that cannot be gained elsewhere, and study of the polar ice sheets reveals how the Earth's climate has changed in the past and provides information essential to predicting future change. Polar regions also offer unusual opportunities for environmental research, as the sensitivity of polar ecosystems to small changes in climate renders them important bellwethers for abrupt or potential future change. An additional area of forefront research probes how organisms have adapted to the extreme polar environment using recently-developed techniques of molecular biology.

Since FY 2006, NSF has funded the operation and maintenance of the United States Coast Guard's (USCG) three polar icebreakers: *Polar Sea*, *Polar Star*, and *Healy*. The agencies cooperate under a Memorandum of Agreement that includes guidance for planning and scheduling. It sets forth the terms and conditions for reimbursement to the USCG from NSF. NSF and the USCG work together to formulate operations and maintenance plans and associated funding requirements. NSF is responsible for ascertaining the needs of other federal agencies, and for securing USCG program plans to accommodate them, on a reimbursable funding basis. Effective with the FY 2009 budget, NSF will no longer provide funds to maintain the *Polar Star* in caretaker status because NSF does not envision current or future use of this vessel in support of its mission.



NOTE: US Antarctic Logistical Support Activities are shown separately from the Antarctic Infrastructure & Logistics Division, where it is administered.

RELEVANCE

Research in polar regions offers opportunities for fundamental advances in each of the disciplinary sciences, ranging from the behavior of the Earth's inner core, the formation of galaxies, the biology of life in the cold and dark, and how Arctic residents and institutions are affected by environmental change. In addition, it addresses polar aspects of the global earth system – glacial and sea ice, terrestrial and marine ecosystems, the ocean, and the atmosphere – that help shape the global environment and climate. OPP continues to make these investments in climate change research and environmental observations a high priority. OPP funding will continue to support development and implementation of the enhanced observation systems needed to trace these shaping influences on a regional basis. It will also support research to elucidate the interactions among them and how they impact the polar environment. The work will include studies of the natural climate records from the past contained in ice cores and earth sediments. Much of this research will be carried out in collaboration with scientists in other countries, promoting international partnerships.

NSF provides interagency leadership for U.S. activities in both polar regions. In the Arctic, NSF leads research planning as directed by the Arctic Research Policy Act of 1984. The NSF Director chairs the Interagency Arctic Research Policy Committee (IARPC) created for this purpose. In addition, per Presidential Decision Directive, NSF manages all U.S. activities in the Antarctic as a single, integrated program, making research possible in Antarctica by scientists supported by NSF and by U.S. mission agencies. The latter include the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, the Smithsonian Institution, and the Department of Energy. The U.S. Antarctic Program supports the U.S. governance role through the Antarctic Treaty.

International Polar Year:

In FY 2009, NSF will continue funding for research, education, and infrastructure projects initiated during International Polar Year (IPY) 2007-2009. The vision for IPY established by the National Academy of Sciences/Polar Research Board includes an "… intense, coordinated campaign of polar observations, research, and analysis that will be multidisciplinary in scope and international in participation…. that will benefit society by exploring new frontiers and increasing understanding of the key roles of the polar regions in globally linked systems."

As the lead agency supporting polar research, NSF is providing U.S. leadership in IPY through the work of its grantees. In coordination with other agencies, NSF is also providing the associated logistics and infrastructure support that is essential to conducting that research, and is developing partnerships with other nations that leverage NSF resources. In FY 2006, emphasis was placed on establishing an Arctic Observing System in support of the Study of Environmental ARctic CHange (SEARCH), on Polar Ice Sheet Dynamics and Stability, and on studies of Life in the Cold and Dark, particularly at the genomic level. Work in FY 2007 and FY 2008 builds on these themes and expands to new ones identified in research community planning activities. These include understanding and characterizing environmental change through studies of systems and drivers, impacts on subsystems, and interactions among components of Earth's systems.

While IPY will officially close in March 2009, OPP will continue to leverage these investments to further our knowledge and understanding of climate history and change, of the resulting human impacts, of ice sheet dynamics and history, and of life in the cold and dark. In FY 2009, funding will support IPY synthesis activities that will bring U.S. researchers, the international science community, and students from all disciplines together to address interdisciplinary challenges such as obtaining an integrated understanding of environmental change in the Arctic, and advancing understanding of the Antarctic system in a global context as well as advancing understanding of biotic systems during times of change.

IPY and its legacies involve people of all ages, from all walks of life, and from diverse backgrounds – from teachers to students and artists to scientists – engaging them in the scientific discoveries that will evolve from this international, collaborative research. Through education and outreach, the importance of science and engineering in understanding earth systems will be showcased. IPY provides an ideal opportunity to advance this goal by involving students in the international research venture and by enabling U.S. scientists to maintain a leadership role in a wide range of international activities.

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, OPP………………..…………………………………………………………..$442.54

Arctic Sciences +$13.12

Funding increases for a broad range of activities to provide an integrated understanding of environmental change in the Arctic, including study of significant, system-scale environmental change and its human dimension. Other priorities include investments to improve access and capacity and to introduce alternative energy solutions – e.g., wind power generation and energy efficient construction materials – at Summit Station, Greenland, and other Arctic stations. The program will investigate the use of over-snow traverses to mitigate the rising cost of aviation support.

Antarctic Sciences +$10.89

Support increases for synthesis activities to advance understanding of the Antarctic system in a global context as well as advancing understanding of biotic systems during time of change. Other priorities that have had to be deferred from FY 2008 include funds to enable Antarctic Sciences to explore, in collaboration with Swedish scientists, research questions related to oceanography in the Southern Ocean; funds to support development of instrumentation and equipment for making critical scientific observations with the potential to transform data collection, monitoring and modeling for marine, terrestrial, cryospheric, atmospheric, biotic, and system science; and operations and research funding for the IceCube Neutrino Observatory.

Antarctic Infrastructure and Logistics +$26.66

Funding is provided to continue implementation of critical infrastructure projects necessary to diversify and improve the resupply capability to support McMurdo and South Pole Stations, and to ensure the continuity of pier-side cargo and personnel embarkation and debarkation at Palmer Station. Other priorities include improving the efficient use of utilities and capturing heat generated from station generators at McMurdo Station, Antarctica, and continuing replacement of inefficient legacy software systems with more supportable and secure systems designed for the more sophisticated computer operating systems in use today. Funding increases for costs associated with military aircraft and resupply and research vessel operations.

Polar Environment, Safety and Health +$0.76

Funding will increase for safety and health program oversight, and measures to safeguard the health and safety of researchers and support personnel. Increased funding will continue recognized environmental leadership in the international community through development of stewardship material, training, and management plans.

U.S. Coast Guard Polar Icebreakers -$3.00

Since FY 2006, NSF has been responsible for funding the USCG's three polar icebreakers. Beginning in FY 2009, NSF will no longer fund costs associated with maintaining the USCG's *Polar Star* in caretaker status since it serves no current or foreseeable future purpose with regard to NSF's needs.

Subtotal, Changes +$48.43

FY 2009 Request, OPP…………………………………………………………………………..$490.97

Summary of Major Changes in Office-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, OPP…………………………………………………………………………$442.54

<u>Discovery</u> +$16.65

In the Arctic, completed funding commitments (Shelf Basin Interactions – $2.0 million; tundra manipulation project in Barrow – $1.0 million) and reallocation of funding ($16.60 million, from prior year ending awards) will allow OPP to build upon the success of IPY by expanding investigation into additional areas of critical importance. For example, in FY 2009: providing research and logistics support for ice and sediment coring projects ($6.0 million); enhancing the Arctic Observing Network (AON) ($12.0 million), an internationally-supported, sustainable network to provide critical observations of the Arctic environment and using cyberinfrastructure tools to form a true network from the existing sites; documenting endangered languages ($600,000); and studying humans in a changing ecosystem ($1.0 million). These areas address R&D priorities related to "climate change" and "environment".

In the Antarctic, reallocation of funding and shifts in priorities (ANDRILL – $1.50 million; GPS Network – $1.0 million; AGO – and $1.50 million; Transantarctic Mountains Camp – $3.0 million) will allow OPP to build upon the success of IPY by expanding investigation into additional areas of critical importance. For example, in FY 2009: initiating a new program in Antarctic Integrated and System Science ($3.0 million); continuing the second phase of a sediment coring project ($2.0 million); and emphasizing development of prototype gliders and related oceanographic instruments to develop a long-term record of environmental conditions in the Southern Ocean and associated atmosphere ($2.0 million). These areas address R&D priorities related to "climate change" and "understanding complex biological systems". The amounts shown below do not include offsets of $890,000 for OPP's investments under the Learning and Stewardship goals.

Climate Change Research (+$7.02 million).

Accelerate climate change research and the associated observing and modeling systems, with increased emphasis on human impacts. These projects foster advancement, collaboration and innovation on the complex scientific inquiry into climate change, involving and strengthening international partnerships to accelerate the progress of science worldwide.

IPY Synthesis (+$1.97 million).

While analysis of data sets associated with IPY projects will be ongoing beyond FY 2009, a key goal of IPY is to create a lasting legacy of data, knowledge, and new scientists. In FY 2009, funds will support IPY synthesis activities that will bring U.S. researchers, the international science community, and students together to provide an integrated understanding of environmental change in the Arctic, and to advance understanding of the Antarctic system in a global context as well as advancing understanding of biotic systems during time of change. The IPY synthesis activity supports the ACI goal of enabling scientific advancement through modeling and simulation across a broad range of scientific disciplines.

IceCube Neutrino Observatory research (+$2.79 million).

Construction is sufficiently advanced that initial research activities are underway; hence, operations funding is ramping up toward the steady state. In FY 2007 and FY 2008, funds were provided from core programs to begin science operations and research exploitation in anticipation of reaching full steady state operations in FY 2009. A targeted investment in this area is critical to allow IceCube to be successful in achieving its research goals while maintaining reasonable opportunities in core research programs.

Oden Science (+$350,000).

Funds will enable Antarctic Sciences to explore, in collaboration with Swedish scientists, research questions related to oceanography in the Southern Ocean. These include, for instance, processes related to sea ice formation and formation of Antarctic bottom water, as well as processes related to primary productivity and carbon sequestration. These activities exploit the capabilities of the research platform *Oden*. The *Oden* is capable of working in ice-covered waters not accessible to NSF's other research platforms (the *Nathaniel B. Palmer* and the *Laurence M. Gould*). The new Implementing Arrangement with Sweden that brings *Oden* to the Southern Ocean opens up new opportunities for research ranging from physical oceanography to the study of ice-covered ecosystems. Funds to charter *Oden* are provided through the Division of Antarctic Infrastructure and Logistics.

Remote Sensing Instrumentation (+$5.41 million).

Emerging and important research subjects in Antarctica cannot be readily investigated in the traditional "boots on the ground" manner owing to questions of accessibility. In order to advance scientific discovery, investments in instrumentation for remote sensing will be essential. In FY 2009, funds will support development of instrumentation (sensors, communications, etc.) and equipment for making critical scientific observations, either as remote installations, as sensors mounted on vehicles or aircraft, or as instruments critical for the scientific analysis of these observations. These investments have the potential to transform data collection, monitoring and modeling for marine, terrestrial, cryospheric, atmospheric, biotic, and system science. System science, an interdisciplinary approach with the potential to further understanding of Antarctic climate change, emerged from the FY 2007 IPY solicitation as a forefront research frontier that merits significantly increased funding. The portfolio would make extensive use of cyberinfrastructure, allowing a larger research community to participate in the research and enabling opportunities to increase the outreach activities of polar scientists.

<u>Learning</u> +$0.39

Integrative Graduate Education and Research Traineeships (IGERT) increase, providing partial support for an additional IGERT award.

<u>Research Infrastructure</u> +$30.12

Through funds made available from projects expected to be completed in FY 2008 (Microwave Landing System – $1.0 million; Fuel Tanks and Refueling Station – $2.50 million; and McMurdo Power Plant – $1.50 million), OPP will continue to enhance the critical infrastructure required to conduct research in Antarctica. For example, in FY 2009: install the shield for the South Pole 10M Telescope ($2.0 million); and fund increases in the cost of fuel ($3.0 million). The amounts shown below do not include offsets of $770,000 for OPP's investments under the Learning and Stewardship goals.

IceCube Neutrino Observatory operations (+$650,000).

Construction is sufficiently advanced that initial research activities are underway; hence, <u>operations</u> funding is ramping up toward the steady state. In FY 2007 and FY 2008, funds were provided from core programs to begin science operations and research exploitation in anticipation of reaching full steady state operations in FY 2009. A targeted investment in this area is critical to allow IceCube to be successful in achieving its research goals while maintaining reasonable opportunities in core research programs.

U.S. Antarctic Program Resupply (+$22.66 million).

Significant funding above the FY 2008 appropriation is essential to diversify and improve the resupply capability to support McMurdo Station, and to ensure the continuity of pier-side cargo and personnel embarkation and debarkation at Palmer Station. The present pier is nearing the end of its useful life, and without these investments it could represent a safety hazard. FY 2009 investments include initiation of contracts to replace the Palmer Station Pier (+$8.0 million), continuing construction of additional fuel storage capacity at McMurdo Station (+$4.0 million), initial procurement of a second heavy traverse for resupply of South

Pole Station ($2.0 million), and consolidation of the McMurdo area runways into a single operational site at the Pegasus Airfield (+$2.5 million). Additional funding for increases in costs, principally fuel, associated with military aircraft and re-supply and research vessel operations ($5.39 million) is provided.

Energy Efficiency and Fuel Conservation (+$8.82 million).
Investments to improve year-round access, capacity, effectiveness and energy efficiency at NSF-supported field stations in the Arctic ($5.82). At McMurdo Station, Antarctica, investments ($3.0 million) will be made to improve the efficient use of utilities and to capture heat generated from station generators. Major investments include: extension of the waste-heat loop; replacement of heat-trace piping; installation of energy monitoring equipment and instrumentation; and upgrades to the power, water, and utility distribution systems.

USAP IT Network (+$1.0 million).
Funding will continue replacement of legacy software systems. These systems are used to manage the requisitioning of supplies and the tracking of cargo, as well as for managing personnel movements. Designed decades ago and inefficient, OPP can benefit from systems since developed by companies such as FedEx and DHL, and from systems designed for the more sophisticated computer operating systems in use today. Early estimates indicate that the total cost of this project could reach $12 million over a five-year period.

Environment, Safety & Health (+$760,000 million).
Funding will increase for safety and health program oversight, and measures to safeguard the health and safety of researchers and support personnel. Increased funding will be used for additional health and safety measures to support IPY "winter science", acquiring state-of-the-art oxygen regulators for the scientific diving program, electronic information technology and protection of confidential health information, as well as enhancements to the environmental stewardship program to continue recognized environmental leadership in the international community.

U.S. Coast Guard Polar Icebreakers (-$3.0 million).
Since FY 2006, NSF has been responsible for funding the USCG's three polar icebreakers. Beginning in FY 2009, NSF will no longer provide funds for maintaining the USCG's *Polar Star* in caretaker status.

<u>Stewardship</u> +$1.27

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$48.43

FY 2009 Request, OPP…………………………………………………………………………..$490.97

NSF-WIDE INVESTMENTS

In FY 2009, OPP will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

OPP NSF-wide Investments
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Climate Change Science Program	10.50	$10.50	$18.30	$7.80	74.3%
Cyberinfrastructure	43.70	26.24	26.24	-	-
Human and Social Dynamics	0.20	0.20	-	-0.20	-100.0%
International Polar Year	48.48	47.27	1.69	-45.58	-96.4%
Mathematical Sciences	0.10	-	-	-	N/A

Human and Social Dynamics and Mathematical Sciences: With the conclusion of these priority areas in FY 2007 or FY 2008, key components of these investments will be retained through core programs.

Climate Change Science Program (CCSP): CCSP provides the Nation and world with the science-based knowledge to predict change, manage risk, and take advantage of opportunities resulting from climate change and climate variability. OPP focuses on climate change in the polar regions, as well as interactions with the global climate. In FY 2009, investments increase for IPY activities associated with CCSP.

Cyberinfrastructure (CI): CI support will be provided for the Arctic System Science (ARCSS) Data Coordination Center that serves as a central point for deposition of data deriving from ARCSS-funded research. Support is also provided for Arctic modeling, distributed field sites, and autonomous flux towers. In the Antarctic, funds support data center/data repositories, 3-D bathymetric data fusion, and environmental monitoring, both marine and terrestrial. In addition, support is provided for the engineering, operations and maintenance, and security of information technology systems.

International Polar Year (IPY): With the conclusion of this event in March 2009, continued funding for International Polar Year activities will, as described throughout this chapter, be provided from core programs. In FY 2009, OPP will support IPY synthesis activities.

QUALITY

OPP maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. The share of research funds that were allocated to projects that undergo external merit review was approximately 86 percent in FY 2007, the last year for which complete data exist. OMB's definition of competitive, merit-based review does not include contracts, therefore the U.S. Antarctic Program support contract, although a competitively bid contract that undergoes a high degree of review, both internal and external, is not considered competitive, merit-based review for this calculation. If included, it would raise the percentage significantly.

To ensure the highest quality in processing and recommending proposals for awards, OPP convenes Committees of Visitors (COV), composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. The Antarctic programs providing infrastructure, logistics, and environment, health and safety support will be reviewed in FY 2008. The science programs were reviewed in FY 2006, and the overall determination was that they are operating well. They will be reviewed again in FY 2009.

OPP also receives advice from its Advisory Committee (AC) on issues such as: the mission, programs, and goals that can best serve the scientific community; how OPP can promote quality graduate and undergraduate education in the sciences it supports; and priority investment areas in polar research. The AC meets twice a year. Members represent a cross-section of polar research, with representatives from different disciplines, and include a balanced representation of gender, members of underrepresented groups, and geographic regions.

PERFORMANCE

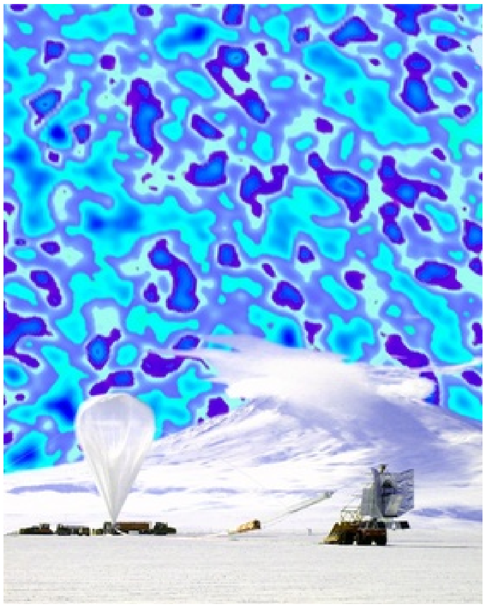
The FY 2009 Budget Request is aligned to reflect funding levels associated with the four strategic outcome goals stated in the Foundation's FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education, and facilitate budget and performance integration.

Office of Polar Programs
by Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate	
				Amount	Percent
Discovery	$107.77	$104.04	$120.69	16.65	16.0%
Learning	3.88	5.19	5.58	0.39	7.5%
Research Infrastructure	324.24	331.02	361.14	30.12	9.1%
Stewardship	2.53	2.29	3.56	1.27	55.5%
Total, OPP	$438.43	$442.54	$490.97	$48.43	10.9%

Recent Research Highlights

► **Balzan Prize Awarded for BOOMERANG:** Andrew Lange of the California Institute of Technology shared the 2006 Balzan Prize for Astronomy and Astrophysics – worth 1 million Swiss francs--with an Italian colleague. The pair received the honor for their pioneering work in using a balloon-based observatory to study the Cosmic Microwave Background radiation, which is essentially the afterglow of the "Big Bang," the primordial expansion that marks the beginning of the universe. The atmospheric circulation over Antarctica allows balloons that are released near McMurdo Station, NSF's logistics hub in Antarctica, to circle the continent and return to be retrieved almost at the point of launch. Lange's experiment, BOOMERANG (Balloon Observations Of Millimetric Extragalactic Radiation and Geomagnetics), took advantage of these unique conditions to obtain important clues to the processes that were active at the beginnings of the universe. (ANT)



The sky above Mt Erebus, Antarctica, as it would appear if one had eyes sensitive to the microwave energy measured by the Boomerang telescope. Long Duration Balloon Launch underway in foreground. *Credit: BOOMERanG Team.*

► **Inuit and Scientific Studies of the Narwhal: Connecting Parallel Perceptions:** A team of researchers led by an NSF-funded scientist from the Harvard School of Dental Medicine has discovered that the spiral tooth of the narwhal – a creature that has long been reputed to have magical properties – actually does have some extraordinary abilities that rival the myths and lore. The tooth acts as a sensor, allowing the animal to sample water temperature, pressure, the presence of particles, and motion. The tusk was previously believed by scientists solely to be a weapon for aggressive males seeking to establish social hierarchy. The new findings open a myriad of possibilities for future study and more than 60 scientists have joined in the research into the tusk's properties. The study also is novel in that the principal researcher incorporates traditional knowledge from indigenous people into their research about narwhal behavior. (ARC)

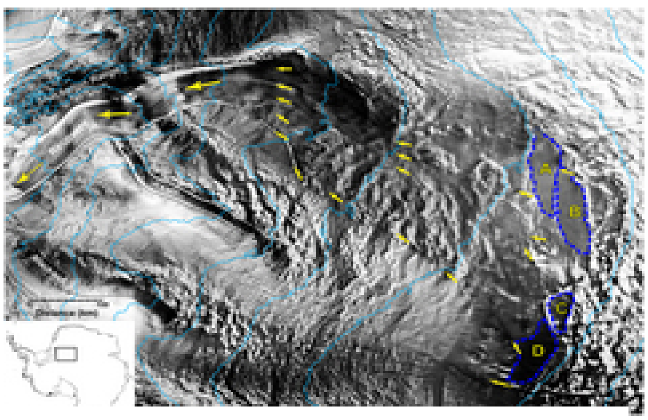
Narwhal come up for air in an ice lead during spring. *Credit: (c) Glenn Williams.*

► **Understanding the Arctic Freshwater Cycle:** A new analysis of 50 years of changes in freshwater flows into the Arctic Ocean and North Atlantic may help shed light on what is causing a recently observed freshening of the North Atlantic. NSF-funded research resulted in a big-picture view of Arctic hydrologic trends, the first effort of its kind. The analysis revealed that freshwater increases from Arctic Ocean sources appear to be strongly linked to changes in the North Atlantic. The researchers noted a relationship between increases in freshwater inputs, rising air temperatures, and a climate phenomenon known as the North Atlantic Oscillation and the associated Northern Annular Mode index. While they said the complex interaction of these phenomena will determine whether the oceans continue to freshen, they also cautioned it is difficult to predict future trends. (ARC)

Photo of ANDRILL drill system on McMurdo Ice Shelf during the austral summer of 2006/2007. *Credit: Peter Rejcek.*

► **Geological Drilling in the Antarctic for Climate History:** The Antarctic Geological Drilling (ANDRILL) program, an international paleoclimate project, has drilled to a record depth of 1284.87 meters (4,200 feet). Researchers recovered sediment cores from beneath the Ross Ice Shelf and underlying waters that represent a nearly unbroken geological history reaching back 5 million years. The cores revealed that the ice shelf and adjoining ice sheet advanced and retreated more than 50 times during that time. A team of 58 scientists, technicians, educators, and support staff from the U.S., New Zealand, Italy, and Germany spent three months at McMurdo Station studying the core and documenting how Antarctic ice sheets behaved during periods when the globe was much warmer. Additional study of the core will hopefully provide a picture of how the ice sheets might react to increasing global temperatures. (ANT)

► **Discovery of a Possible Link Between Subglacial Lakes and Ice Streams:** An NSF-funded research team at Columbia University's Lamont-Doherty Earth Observatory has discovered a possible link between the lakes that are known to exist beneath the miles-thick Antarctic ice sheets and the sources of ice streams that drain the East Antarctic ice sheet. The research team believes that the lakes provide a source of water that lubricates the bed of the glaciers and, in turn, speeds up the flow of ice. Working with NASA scientists, the researchers also found four new subglacial lakes that coincide with the origin of tributaries of Recovery Glacier ice stream. This work follows from their previous pioneering research on Lake Vostok, a subglacial lake the size of Lake Ontario, by providing a better understanding of subglacial lakes and how they work. (ANT)



Combined RADARSAT (RAMP) imagery and ICESat elevation data showing the Recovery Ice Stream (arrows) and location of four new subglacial lakes (A, B, C and D) that lie at the head of the stream. *Credit: Christopher Shuman and Vijay Suchdeo, NASA.*

► **Stellar Axis: Antarctica:** An NSF Antarctic Artist and Writers Grant recipient has conceived of Stellar Axis: Antarctica, an art expedition to Antarctica that entails a tracing of the stars above the North and South Pole onto the ice at both poles. The grantee, along with an international team of scientists and journalists, positioned ninety-nine blue spheres in alignment to the stars over the South Pole onto the Ross Ice Shelf. A performance indicating the motion of the stars at the poles was filmed to share with audiences upon their return. An arts educator, grantee Lita Albuquerque's work impacts her students and the public through lectures and exhibits. "By doing a star alignment on the ice at both poles, it engages

Blue spheres secured into the Ross Ice Shelf represent the stars above in Stellar Axis. In the distance, the artist and a team member survey their work. *Credit: Jean de Pomereu.*

the whole planet," says Albuquerque. "I'm interested in creating a mental image of the patterns aligning. It's like taking a snapshot of a moment in time when the stars are aligned to the pattern on the ground, so that the “picture” is an accurate picture of a vast circulatory system of stars of which we are a part." (ANT)

► **Discovery of a baby plesiosaur in Antarctica:** A new fossil of a baby plesiosaur, the sea reptile considered the prototype of the mythical Loch Ness Monster, has been discovered in Antarctica. The skeleton had a long neck and a hydro-dynamically shaped body propelled by four paddles and dates to the end of the Age of Dinosaurs, about 70 million years ago. It's one of only a handful known worldwide and is so well preserved that stomach ribs and stomach stones are in life position. Stomach stones are thought to have been utilized for aid in digestion and/or for diving. The specimen indicates these stones were ingested while the creatures were very young, a question scientists have pondered for years. The hardening of the bones was not yet completed when the baby died, and premature death may have come through volcanism. Large chunks of pumice and volcanic ash were found with debris of a tree entombed with the plesiosaur, suggesting a blow-down of vegetation may have occurred similar to that documented during the eruption of Mt. St. Helens. (ANT)

A researcher carefully excavates a fossilized juvenile plesiosaur on Vega Island, Antarctica. *Credit: James E. Martin, South Dakota School of Mines and Technology.*

Other Performance Indicators

The tables below show the number of people benefiting from OPP funding, and trends in award size, duration, number of awards, and funding rate.

Number of People Involved in OPP Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	1,140	1,170	1,190
Other Professionals	739	760	770
Postdoctorates	142	145	150
Graduate Students	427	440	450
Undergraduate Students	265	270	280
Total Number of People	2,713	2,785	2,840

OPP Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	372	396	402
Funding Rate	31%	32%	32%
Statistics for Research Grants:			
Number of Research Grants	325	341	350
Funding Rate	28%	29%	29%
Median Annualized Award Size	$167,025	$173,825	$178,025
Average Annualized Award Size	$238,398	$245,198	$249,398
Average Award Duration, in years	2.7	3.0	3.0

NOTE: FY 2008 estimates are based on the expected impact of IPY on OPP's funding profile.

Arctic Sciences $103,970,000

The FY 2009 Budget Request for Arctic Sciences (ARC) is $104.12 million, an increase of $13.12 million, or 14.4 percent, over the FY 2008 Estimate of $90.85 million.

Arctic Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Arctic Sciences	**$89.27**	**$90.85**	**$103.97**	**$13.12**	**14.4%**
Major Components:					
Research & Education Projects	52.85	52.67	59.97	7.30	13.9%
Facilities					
Research Support & Logistics	36.42	38.18	44.00	5.82	15.2%

Totals may not add due to rounding.

About Arctic Sciences:

In the 1990's, global atmospheric models began to converge in their predictions that the Arctic would be at the forefront of global climate change. It now appears that those models were reasonably accurate in that regard. Observations have revealed an estimated 14 percent per decade reduction in summer sea ice extent in the Arctic, and significant summer melting of the Greenland Ice Sheet. These and many other phenomena are forcing change and uncertainty in traditional Arctic populations, present challenges and opportunities for industry and commerce, and have the potential to affect the global population through changes in sea level.

Arctic Sciences is organized into several programs that support social science, earth system science and a broad range of natural science. Educational projects are also supported. The Research Support and Logistics program assists researchers with access to the Arctic, improves safety and environmental stewardship, and increases the ability of researchers to share plans and results with local Arctic communities.

The goal of ARC is to gain a better understanding of the Earth's physical, biological, geological, chemical, social, and cultural processes, and the interactions of ocean, land, atmosphere, biological, and human systems in the Arctic. ARC and other NSF programs support projects that contribute to the development of the next-generation of researchers and scientific literacy for all ages through education, outreach, and broadening participation in science, technology, engineering and mathematics. Program representatives from OPP and other NSF programs that support arctic research coordinate across NSF, including joint review and funding of arctic proposals and mutual support of special projects with high logistical costs.

In general, 59 percent of the ARC portfolio is available for new research grants. The remaining 41 percent funds continuing grants made in previous years, and research support and logistics.

Arctic Sciences Priorities for FY 2009:

- **Understanding Environmental Change in the Arctic —** Increase the use of modeling and synthesis to determine the nature and extent of current Arctic-system scale changes and the role of these changes as part of the global system.
- **Arctic Observing Network —** Continue to enhance an internationally supported, sustainable network to provide critical observations of the Arctic environment and use cyberinfrastructure tools to form a true network from the existing group of sites.
- **Bering Sea Ecosystem Study —** The eastern Bering Sea supports highly productive marine ecosystems that annually generate roughly 50 percent of all fish and shellfish landings in the United States. Models and observations suggest that the ecosystem will experience change. The Bering Sea Ecosystem Study is designed to develop an understanding of the effects of a varying sea-ice cover on the shelf ecosystem, project the potential changes in response to anticipated climate variations on decadal time scales, and assess the vulnerability and sustainability of local communities to such changes.
- **Human Systems in Polar Regions —** Humans have been an integral part of the arctic polar environment for the last 10,000 or more years. Indigenous peoples as well as recent migrants into the region have influenced and been influenced by the natural environment. IPY will encourage studies that advance the understanding of our species' place in the complex system of polar phenomena.
- **Improve Research Infrastructure —** Improve year-round access, capacity, and effectiveness of research sites in Alaska and throughout the Arctic.

Changes from FY 2008:

- In the Arctic, completed funding commitments (Shelf Basin Interactions – $2.0 million; tundra manipulation project in Barrow – $1.0 million) and reallocation of funding ($16.60 million, from prior year ending awards) will allow OPP to build upon the success of IPY by expanding investigation into additional areas of critical importance. For example, in FY 2009: providing research and logistics support for ice and sediment coring projects ($6.0 million); enhancing the Arctic Observing Network (AON) ($12.0 million), an internationally-supported, sustainable network to provide critical observations of the Arctic environment and using cyberinfrastructure tools to form a true network from the existing sites; documenting endangered languages ($600,000); and studying humans in a changing ecosystem ($1.0 million).
- An increase of $7.02 million to accelerate climate change research using both modeling and observational systems including the human aspects of the change.
- An increase of $280,000 to support additional integration of education with research during IPY.
- An increase of $5.82 million to improve year-round access, capacity, effectiveness, and energy efficiency at NSF-supported field stations in the Arctic.

Antarctic Sciences $71,240,000

The FY 2009 Budget Request for Antarctic Sciences (ANT) is $71.24 million, an increase of $10.89 million, or 18 percent, over the FY 2008 Estimate of $60.35 million.

Antarctic Sciences Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Antarctic Sciences	**$56.65**	**$60.35**	**$71.24**	**$10.89**	**18.0%**
Major Components:					
Research & Education Projects	52.20	55.90	67.24	11.34	20.3%
Centers Programs					
STC: Center for Remote Sensing of Ice Sheets	4.45	4.45	4.00	-0.45	-10.1%

Totals may not add due to rounding.

About Antarctic Sciences:

The Antarctic continent and the Southern Ocean constitute about 7 percent of the surface of Earth and are important components of the Earth system. The continent contains records of geological processes that reveal the role of the Antarctic in the long-term evolution of the planet including records of the evolution of life on Earth. The region hosts organisms and ecosystems that have evolved and adapted to survive and thrive in extreme cold and long periods of darkness. The ice sheets hold detailed records of past climatic conditions, including direct samples of the atmosphere, that reach back 800,000 years, and perhaps more. The annual formation and breakup of sea ice around the continent is a major phenomenon that drives ocean circulation and has a major impact on Earth's heat budget. The ice sheets, surrounding ocean, and atmosphere are also key systems that must be understood in order to advance our understanding of sea level change and its role in climate change. In addition to these aspects of understanding the Antarctic and its role in Earth processes, the high plateau of East Antarctica, and South Pole Station in particular, are unrivaled with respect to the conditions they offer for a wide array of astronomy and astrophysical research.

The goal of Antarctic Sciences is to enable research in all areas of science that can only be done, or is best done, in Antarctica. This is done through funding disciplinary and cross-disciplinary programs that encompass the geosciences, biosciences, and physical sciences. ANT enables research on Earth's physical, biological, geological, glaciological, oceanographic, and atmospheric processes in Antarctica as well as on interactions between the ice sheets, the underlying continent, the surrounding ocean, and the overlying atmosphere toward a comprehensive understanding of Antarctica's role in the evolution of Earth and life on Earth, as well as the Antarctic environment's role in the whole Earth system. In particular, a new programmatic emphasis fosters linkages across the disciplines in order to better advance understanding of Antarctic climate as a system. ANT also enables research in astronomy and astrophysics to advance understanding about high energy phenomena such as supernovae and events associated with black holes, about the nature of dark energy and dark matter which is now known to be a major component of the universe, as well as advance general understanding about the origin and evolution of the universe.

In general, 40 percent of the ANT portfolio is available for new research grants. The remaining 60 percent is used primarily to fund continuing grants made in previous years.

Antarctic Sciences Priorities for FY 2009:

- **International Polar Year (IPY) —** Building on partnerships developed during the early stages of IPY, Antarctic Sciences has the following priorities:
  - **East Antarctic Ice Sheet and lithosphere system —** The goal is to achieve a basic understanding of both the ice sheet and underlying lithosphere in central East Antarctica, as well as an understanding of the major processes and interactions that control ice sheet change.
  - **Life in the polar night —** The goal is to advance understanding of seasonal environmental change during the transitions between relative warmth and abundant light of summer and the extreme cold and dark of winter, and to advance knowledge about how organisms and ecosystems have adapted and evolved to survive and thrive.
  - **Paleoclimate records from central West Antarctica —** The goal is to exploit the deep ice core recovered from the WAIS (West Antarctic Ice Sheet)-Divide site for climate records that can be compared to the Greenland Ice Core record to advance understanding of polar climate change, particularly the processes and timing of abrupt climate change.
- **Astronomy and Astrophysics —** Increase the research exploitation phase for two major new discovery instruments – the IceCube Neutrino Observatory and the 10m South Pole Telescope. These two projects are expected to enable discovery of new phenomena and to achieve understanding about the origin and evolution of the universe.

Changes from FY 2008:

- In the Antarctic, reallocation of funding and shifts in priorities (ANDRILL – $1.50 million; GPS Network – $1.0 million; AGO – and $1.50 million; Transantarctic Mountains Camp – $3.0 million) will allow OPP to build upon the success of IPY by expanding investigation into additional areas of critical importance. For example, in FY 2009: initiating a new program in Antarctic Integrated and System Science ($3.0 million); continuing the second phase of a sediment coring project ($2.0 million); and emphasizing development of prototype gliders and related oceanographic instruments to develop a long-term record of environmental conditions in the Southern Ocean and associated atmosphere ($2.0 million).
- **Remote Sensing Instrumentation –** an increase of $5.41 million to support development of instrumentation and equipment required for critical observations in all areas of Antarctic science.
- **IceCube Neutrino Observatory –** an increase of $3.44 million to enable early science operations ($650,000) for the part of the detector array that has been completed (25 of 70 detector strings) and research ($2.79 million) to exploit data returned from the growing array. This represents ANT's contribution to joint funding for IceCube science operations and research with the Division of Physics within the Directorate for Mathematical and Physical Sciences.
- **International Polar Year –** an increase of $1.69 million to support IPY synthesis activities that will bring U.S. researchers, the international science community, and students together to advance understanding of the Antarctic system in a global context as well as advancing understanding of biotic systems during time of change.
- ***Oden* Science** – an increase of $350,000 will enable Antarctic Sciences to explore, in collaboration with Swedish scientists, research questions related to oceanography in the Southern Ocean.

Antarctic Infrastructure & Logistics $255,020,000

The FY 2009 Budget Request for Antarctic Infrastructure & Logistics (AIL) is $255.02 million, an increase of $26.66 million, or 11.7 percent, over the FY 2008 Estimate of $228.36 million.

Antarctic Infrastructure & Logistics Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Antarctic Infrastructure & Logistics	**$233.76**	**$228.36**	**$255.02**	**$26.66**	**11.7%**
Major Components:					
Facilities					
Operations & Science Support	166.24	160.84	187.50	26.66	16.6%
U.S. Antarctic Logistical Support Activities	67.52	67.52	67.52	-	-

Totals may not add due to rounding.

About Antarctic Infrastructure & Logistics:

Operations & Science Support

Antarctic Infrastructure & Logistics supports research through a network of stations, labs, equipment, and logistics that enable research activities in Antarctica. This includes operation of a year-round inland research station at the South Pole (90° south latitude); two year-round coastal research stations (McMurdo at 78°S and Palmer at 64°S) with extensive laboratory, transportation, housing, communication, and computing capabilities; summer camps (as required for research); icebreaking research ships—the *Laurence M. Gould* and the *Nathaniel B. Palmer*; a fleet of ski-equipped LC-130 airplanes operated and maintained by the Air National Guard; U.S. Air Force inter-continental transport; small fixed winged aircraft and helicopters; and icebreakers for channel breaking and ship escort at McMurdo Station.

AIL uses a mix of government and civilian contract service providers to conduct oversight and research support activities in Antarctica. The largest of these contracts is an operations and maintenance contract with Raytheon Polar Services Company of Centennial, Colorado.

Back-up Icebreakers. Since 2004, AIL has contracted with civilian operators to provide back-up icebreaking support to the U.S. Coast Guard due to heavy ice conditions in the McMurdo Sound region and maintenance issues with the USCG polar icebreakers. During FY 2005 and 2006, AIL contracted with FESCO, a Russian company, for the icebreaker *Krasin*. During FY 2007, AIL was able to contract for the services of the Swedish research icebreaker *Oden*. Ice conditions in the McMurdo Sound region appear to be returning to "normal". The USCG, however, continues to recommend that back-up icebreakers be available. This recommendation, together with continuing concerns over the reliability of the USCG polar class icebreakers, makes it prudent to plan to continue to secure back-up icebreaking services in FY 2008 and FY 2009. This cost (approximately $9.0 million) is in addition to the cost of "United States Coast Guard Polar Icebreaking" discussed later.

Transportation and Fuel Cost Increases. Since 2005, AIL has experienced steady increases in the cost of both aviation and vessel operations due to a variety of factors. Aircraft flight hour cost increases for both the Air National Guard and U.S. Air Force, combined with personnel cost increases have significantly increased the cost of services. Charter costs for vessel operations, both through Military Sealift Command and for the icebreaking research ships, have also continued to rise steadily. The USAP is also impacted by market conditions associated with the price of fuel, which is the major contributor to the increase in operations costs.

U.S. Antarctic Logistical Support Activities

The U.S. Antarctic Logistical Support Activities budget line funds support provided by the U.S. Department of Defense (DoD). DoD operates as a primary logistical support provider on a cost-reimbursable basis. Major funding elements of DoD support include: military personnel, LC-130 flight operations, maintenance, and facilities support of the 109th Airlift Wing (AW) of the New York Air National Guard in Scotia, New York and Antarctica; transportation and training of military personnel supporting the U.S. Antarctic Program; support for air traffic control, weather forecasting, and electronic equipment maintenance; the charter of Air Mobility Command Airlift and Military Sealift Command ships for the re-supply of McMurdo Station; bulk fuel purchased from the Defense Logistics Agency; and reimbursement for use of DoD satellites for communications.

Antarctic Infrastructure & Logistics Priorities for FY 2009:

- A major focus for AIL in FY 2009 is support of legacy IPY activities, including continuing extensive field efforts in West Antarctica for studies of Ice Sheet Dynamics.
- The ability to resupply McMurdo and South Pole stations will be diversified and strengthened as the fuel storage capacity at McMurdo station is increased and the surface traverse to South Pole becomes operational.
- Two additional capital infrastructure projects include increasing the high bandwidth communication capability at the South Pole to support the 10m South Pole Telescope and IceCube, and the initiation of contracts for construction to replace the pier at Palmer Station which is critical to allow resupply ships to dock at the station**.**
- Due to the strong effect of market forces on the cost of fuel, major emphasis will be put towards improving fuel and energy efficiency at Antarctic stations.

Changes from FY 2008:

- Through funds made available from projects expected to be completed in FY 2008 ($5.0 million), OPP will continue to enhance the critical infrastructure required to conduct research in Antarctica. For example, install the shield for the South Pole 10M Telescope; and fund increases in the cost of fuel.
- An increase of $4.0 million to restore funding for the procurement and construction of additional fuel tanks at McMurdo Station.
- An increase of $8.0 million to construct the Palmer Station Pier.
- An increase of $2.0 million to restore funding for the South Pole heavy traverse swing.
- An increase of $2.50 million to consolidate the McMurdo area runways into a single operational site at the Pegasus Airfield.
- An increase of $3.0 million to improve the efficient use of utilities and to capture heat generated from McMurdo Station generators.
- An increase of $1.0 million to continue replacement of legacy software systems to improve supportability and security.
- Additional funding for increases in costs associated with military aircraft and re-supply and research vessel operations ($6.16 million).

Polar Environment, Safety & Health $6,740,000

The FY 2009 Budget Request for the Polar Environment, Safety & Health (PESH) is $6.74 million, an increase of $760,000, or 12.7 percent, over the FY 2008 Estimate of $5.98 million.

About Polar Environment, Safety & Health:

Polar Environment, Safety & Health Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Polar Environment, Safety & Health	**$5.79**	**$5.98**	**$6.74**	**$0.76**	**12.7%**

Established in December 2005, the Polar Environment, Safety & Health Office within OPP manages and oversees the environmental, safety, and health aspects of research and operations conducted in polar regions. PESH has overall responsibility for guiding the implementation of both environmental protection and stewardship to minimize the environmental impact of OPP-supported activities in polar regions. PESH also develops and oversees programs to ensure the safety and health of all participants. PESH ensures compliance with environmental, safety, and health related regulatory, statutory, and international treaty requirements.

Polar Environment, Safety & Health Priorities for FY 2009:

- **Environment** – develop environmental stewardship material, training, and management plans.
- **Safety & Health** – review, update, and complete a USAP Safety Manual; revise the USAP Medical Screening Guidelines to reflect advances in medicine and on-ice diagnostic and treatment capabilities; and identify and address health and safety risk factors responsible for illnesses and injuries in the polar regions.

Changes from FY 2008:

Increased funding will be used for additional health and safety measures to support IPY "winter science", acquiring state-of-the-art oxygen regulators for the scientific diving program, electronic information technology and protection of confidential health information, as well as enhancements to the environmental stewardship program.

United States Coast Guard Polar Icebreaking $54,000,000

The FY 2009 Budget Request for United States Coast Guard (USCG) Polar Icebreaking is $54.0 million, a decrease of $3.0 million, or 5.3 percent, from the FY 2008 Estimate of $57.0 million.

USCG Polar Icebreaking Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
USCG Polar Icebreaking	**$52.96**	**$57.00**	**$54.00**	**-$3.00**	**-5.3%**

About U.S. Coast Guard Polar Icebreaking:

Since FY 2006, NSF has funded the operation and maintenance of the USCG's three polar icebreakers: *Polar Sea, Polar Star,* and *Healy*. The agencies cooperate under a Memorandum of Agreement that includes guidance for planning and scheduling. It sets forth the terms and conditions for reimbursement to the USCG from NSF. NSF and the USCG work together to formulate operations and maintenance plans and associated funding requirements. NSF is responsible for ascertaining the needs of other federal agencies and for securing USCG program plans for accommodating them, on a reimbursable funding basis. Effective with the FY 2009 budget, NSF will no longer provide funds to maintain the *Polar Star* in caretaker status because NSF does not envision current of future use of this vessel in support of its mission.

NSF convened an external expert review of the USCG's requests for maintenance funding for the *Polar Sea* and the *Healy*. The review may validate a requirement to perform more or less maintenance on the ships pending a national policy determination.

This USCG icebreaking cost is in addition to the cost of back-up icebreakers discussed in "Antarctic Infrastructure & Logistics."

INTEGRATIVE ACTIVITIES $276,000,000

The FY 2009 Budget Request for Integrative Activities (IA) is $276.0 million, an increase of $43.73 million, or 18.8 percent, above the FY 2008 Estimate of $232.27 million.

Integrative Activities Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Integrative Activities[1]	$219.45	$232.27	$276.00	$43.73	18.8%
EPSCoR	*102.11*	*111.10*	*113.50*	*2.40*	*2.2%*

[1] Funding for EPSCoR is shown for all years for comparability. EPSCoR was transferred from the Education and Human Resources appropriation to the Research and Related Activities appropriation in FY 2008.

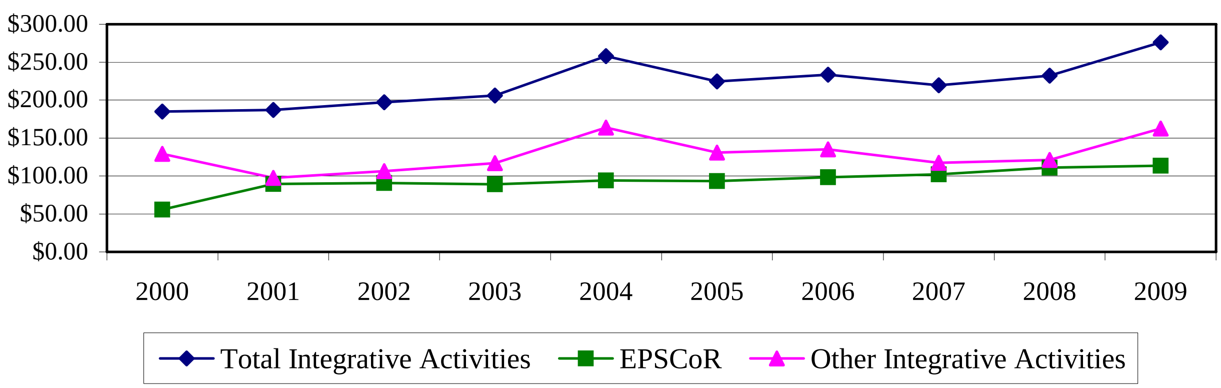
RELEVANCE

Integrative Activities supports emerging, cross-disciplinary research and education, recognizing the importance of integrative efforts to the future of science and engineering. IA is a source of federal funding for the acquisition and development of research instrumentation at U.S. academic institutions and for strengthening the research and educational infrastructure throughout the Nation. Also supported are a number of integrative research and education centers and programs that enhance NSF research investments in discovery and workforce development.

Funds appropriated to IA are managed by a variety of organizations within NSF, which provides the flexibility to broaden support for emerging, cross-disciplinary research programs and activities. For example, the Science and Technology Centers program currently funds 17 centers that are managed cooperatively by six NSF directorates/offices and the Office of Integrative Activities. EPSCoR maximizes cross-directorate interaction and ensures the integration of its efforts with the research and education directorates.

Integrative Activities Funding

(Dollars in Millions)



Integrative Activities Funding by Program

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Communicating Science Broadly[1]	*[$3.80]*	*[$4.00]*	$4.00	$4.00	N/A
EPSCoR[2]	102.11	111.10	113.50	2.40	2.2%
Major Research Instrumentation	90.00	93.90	115.00	21.10	22.5%
Partnerships for Innovation	9.19	9.19	9.56	0.37	4.0%
Science & Technology Centers	1.19	0.90	15.90	15.00	1666.7%
Science & Tech. Policy Institute[3]	4.32	2.24	3.04	0.80	35.7%
Science of Learning Centers	12.64	14.94	15.00	0.06	0.4%
Total, Integrative Activities	$219.45	$232.27	$276.00	$43.73	18.8%

Totals may not add due to rounding.

[1] Communicating Science Broadly is presented in FY 2007 and FY 2008 for information purposes only and is not included in totals for these years or in change amounts or percents for any years. This effort was funded through Research and Related Activities Program

[2] Funding for EPSCoR is shown for all years for comparability. EPSCoR was transferred from the Education and Human Resources appropriation to the Research and Related Activities appropriation in FY 2008.

[3] Funding for the Research and Development in the US (RaDiUS) database is reflected in FY 2007 Actuals and FY 2008 Estimate.

Summary of Major Changes in Agency-Wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, IA.....................................…………………………………………………....$232.27

Discovery

Experimental Program to Stimulate Competitive Research (EPSCoR) +$2.40

With an increase of $2.40 million over the FY 2008 Estimate, funding for EPSCoR will total $113.50 million. This increase will provide $2.0 million for Research Infrastructure Improvement (RII) for multi-jurisdictional cyberinfrastructure (new RII Track 2 awards) and $400,000 for workshop-based outreach activities that build jurisdictional and regional research capacity. Co-funding will be supported at the level of the FY 2008 Estimate. At the FY 2009 Request, EPSCoR investment priorities are: 1) improved competitiveness of EPSCoR jurisdictions in disciplinary and multidisciplinary research programs across NSF, including large scale and cross-cutting competitions; 2) strengthened cyberinfrastructure critical to advances in research and education in all EPSCoR jurisdictions; and 3) increased diversity that is essential to greater use of the human and institutional resources in EPSCoR jurisdictions. To maintain the rich synergy among EPSCoR and research and education directorates and offices, the FY 2008 Estimate for EPSCoR is $111.10 million. This proposed allocation includes a 1.1 percent increase over the FY 2007 current plan plus $8.0 million.

Science and Technology Centers: Integrative Partnerships (STC) +$15.00

FY 2009 funding of $15.9 million will support a new STC competition in which five to seven new STCs are expected to be named. At the same time, five centers established in FY 2000 will be in their tenth and final year of NSF support.

The Science and Technology Centers: Integrative Partnerships program advances discovery and innovation in science and engineering through the integration of cutting-edge research, excellence in education, targeted knowledge transfer, and the development of a diverse workforce while broadly advancing the goals and objectives of the Administration's American Competitiveness Initiative (ACI) and the America COMPETES Act. The STC research portfolio reflects the disciplines of science and engineering supported by NSF. Examples of continuing investment include cyber-security, advanced nano/microfabrication capabilities, new materials and technologies for monitoring water resources and water quality, medical devices, modeling and simulation of complex earth environments for improving their sustainability, and weather/climate prediction.

STCs engage the Nation’s intellectual talent and robustly draw from its full human diversity through partnerships among academia, industry, national laboratories, and government. These partnerships create synergies that enhance innovation and ensure the timely transfer of knowledge and technology from the laboratory to appropriate industries, the application of patents derived from the work of the STCs, the launching of spin-off companies, and creation of job opportunities. Furthermore, STCs have impressive records of publications and research training of American undergraduate students, graduate students, postdoctoral fellows, established researchers, and educators as well as contributions to K-12 education, industry, and other sectors.

Science of Learning Centers (SLC) +$0.06

With an increase of $60,000 over the FY 2008 Estimate, funding for the SLC program will total $15.0 million. These funds provide continuing support for the second cohort of Science of Learning Centers and for programmatic activities, including workshops, Small Grants for Exploratory Research (SGERs), supplements for program infrastructure and development, and administration. The first cohort of SLCs were fully funded in earlier years. SLCs are built around a unifying research focus on science of learning and incorporate a diverse, multidisciplinary environment involving appropriate partnerships with academia, industry, international partners, all levels of education, and other public and private entities.

<u>Learning</u>

Communicating Science Broadly +$4.00

The Request of $4.0 million supports a range of program activities encompassing internet technology, visualization, cable TV, radio, the entertainment industry, public awareness campaigns, and new outreach efforts, including new partnerships with research institutions, state and local governments, and businesses.

A leading-edge, 21^{st} century communications effort is essential for public acceptance and support of science and engineering. “Traditional media” – the once-major television networks, newspapers, and magazines – have given way to countless internet news sites, web logs (or blogs), personal-device downloads, wireless transmissions, and the like, competing among a population that has become highly pluralized in not only its want for information and how (and when) it receives it, but also in its cultural demographics. In today’s technological culture, opportunities for learning abound in both community and personal settings. The new Office of Legislative and Public Affairs effort, “Communicating Science Broadly Through Multi-media Platforms”, will create products and processes that make learning and understanding science, technology, engineering, and mathematics part of everyday life.

Partnerships for Innovation (PFI) +$0.37

With an increase of $370,000 over the FY 2008 Estimate, funding for PFI will total $9.56 million. This will fund one additional award over expected FY 2008 awards, for a total of 12 to 16 awards in FY 2009. The PFI program connects knowledge created in the discovery process to learning and innovation. Goals are to: 1) stimulate knowledge transformation created by the national research and education enterprise into innovations that create new wealth, build strong economies, and improve the national well-being; 2) broaden participation to more fully meet the range of workforce needs of the national innovation enterprise; and 3) enhance enabling infrastructure necessary to foster and sustain innovation in the long-term. In these ways, the PFI program directly addresses key objectives of the American Competitiveness Initiative and the America COMPETES Act. Partnerships must include a U.S. academic institution as lead and a private sector partner; state/local government partnerships are also encouraged.

<u>Research Infrastructure</u>

Major Research Instrumentation (MRI) +$21.10

With an increase of $21.10 million, or 22.5 percent, over the FY 2008 Estimate, funding for MRI will total $115.00 million. This increase allows enhanced support for the acquisition and development of mid-size instruments as recommended by the National Academy of Sciences. During FY 2009 the MRI funding cap will remain at $4.0 million for single instrument acquisition requests submitted by eligible institutions.

Scientific advances in many fields are critically dependent on the development and acquisition of sophisticated instrumentation. MRI is a Foundation-wide, crosscutting program that supports the acquisition and development of instrumentation relating to a number of specific goals and objectives in the ACI, including nanotechnology and nanoscience, computing, the physical sciences, and materials science and engineering. Funding provides for a diverse portfolio of projects that emphasize state-of-the-art instrumentation, access, and training to support modern research approaches, cross-disciplinary research, integration of research and education, public/private partnerships, and assistance to small and minority-serving institutions. Funding also provides for the acquisition and development of state-of-the-art instrumentation that is too costly to be supported through core NSF programs. It promotes partnerships between academic researchers and private sector instrument developers. Approximately $20.0 million supports teaching-intensive and minority-serving institutions, including Historically Black Colleges and Universities, Hispanic-Serving Institutions, Tribal Colleges, and community colleges, with a focus on research training. Cost sharing provisions in the FY 2009 MRI competition will continue to reflect requirements defined by the America COMPETES Act of 2007 and will continue to require cost sharing for Ph.D. granting educational institutions.

In the FY 2007 MRI competition, NSF received 774 proposals and funded 221 for a total of $89.36 million. Minority-serving institutions received 36 awards totaling $11.66 million. Non-Ph.D. granting institutions received 87 awards totaling $21.1 million. Approximately 235 competitive awards are anticipated in FY 2009.

Science and Technology Policy Institute (STPI) +$0.80

In support of the Office of Science and Technology Policy request for the Science and Technology Institute, and consistent with the STPI authorizing statue, NSF sponsors the STPI contract. For this purpose, NSF's FY 2009 Budget Request provides $3.04 million for STPI.

This is a 35.7 percent increase over the FY 2008 Estimate of $2.24 million. The increase returns STPI to recent funding levels and ensures support for technical and analytic assistance for the development of science and technology policy and effective coordination of the federal R&D enterprise.

Subtotal, Changes +$43.73

FY 2009 Request, IA ....……………………………………………………......… $276.00

QUALITY

NSF uses various internal and external mechanisms to ensure the quality and relevance of existing and proposed programs and to help identify new and emerging opportunities that support agency-specific goals. These mechanisms include merit-based review of proposals, Committees of Visitors (COVs) program oversight, advisory committees and other expert panels, National Academies and other reports, workshops, and long-range planning documents.

NSF maximizes the quality of the R&D supported through the use of a competitive, merit-based process. To ensure the highest quality in processing and recommending proposals, NSF convenes COVs, composed of qualified external evaluators, to review each program. These experts assess the integrity and efficiency of proposal review processes and provide a retrospective assessment of the quality of results of NSF's investments. Several programs conduct annual reviews and undergo reviews and assessments of program outcomes via external contractors.

The STC program maintains a variety of ongoing practices that ensures the quality and relevance of program-supported activities during the 10-year duration of each Center. These practices include strategic planning; annual review by an external team of expert site visitors; fourth-year, in-depth competitive review of renewal proposals; peer review of the program and program outcomes, training of NSF technical coordinators; and shared governance between research directorates and the Office of Integrative Activities. Each Center is required to submit an annual report that has a format specifically designed for the program, participate in annual workshops developed for Center directors and the center education network, provide ethics training for Center staff and participants, and maintain and convene annually an external advisory board that provides guidance, advice, and oversight. Each Center submits a list of advisory board members and their affiliations to NSF and the list is reviewed for conflicts of interest. Additionally, STCs have teleconferencing capabilities to maintain communication within the Center and with NSF.

MRI proposal actions are reviewed on a three-year basis by Committees of Visitors (COVs) in the directorates and divisions managing award grants. In addition to these reviews, the program convenes a COV to conduct an overall evaluation of the program every five years. In FY 2005, the MRI program convened a COV during which the external evaluators examined overall program management and processes, proposal actions, and the results of NSF investments from FY 2000 to FY 2004. The COV commended the program for enhancing the research capacity of the science and engineering community. The next overall evaluation of the MRI program will take place in 2010.

The Foundation-wide EPSCoR program ensures quality and relevance in its Research Infrastructure Improvement (RII) grant element through required strategic planning by participants and through biennial performance effectiveness reviews of awards that complement annual reports and COV processes. In its co-funding element, quality, relevance, and transparency are ensured through merit review in cognizant NSF research and education directorates and their subsequent triennial COV processes. In FY 2005 EPSCoR convened a COV during which the panel of external evaluators examined overall program management and processes, proposal actions, and the results of NSF investments from FY 2000 to FY 2004. The COV commended the program for the new directions and innovations initiated by the EPSCoR Office and for increasing the capacity of the program to evaluate and measure program outputs and outcomes. Due to the relocation of EPSCoR to the Office of Integrative Activities in the Office of the Director from the Directorate for Education and Human Resources in FY 2008, the next COV was re-scheduled and will take place in FY 2009.

EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH $113,500,000

The FY 2009 Budget Request for the Experimental Program to Stimulate Competitive Research (EPSCoR) is $113.50 million, an increase of $2.40 million, or 2.2 percent, over the FY 2008 Estimate of $111.10 million.

Experimental Program to Stimulate Competitive Research Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
EPSCoR Funding[1]	$102.11	$111.10	$113.50	$2.40	2.2%

[1] Funding for EPSCoR is shown for all years for comparability. EPSCoR was transferred from the Education and Human Resources appropriation to the Research and Related Activities appropriation in FY 2008.

About EPSCoR:

EPSCoR's mission is to assist the Foundation in its statutory function to strengthen research and education throughout the United States and to avoid undue concentration of such research and education. The primary goals of EPSCoR are: (1) to stimulate sustainable improvements in the R&D capacity and competitiveness within the major research universities of the designated EPSCoR jurisdictions, and (2) to advance scientific and engineering capabilities in these jurisdictions for discovery, innovation, and overall knowledge-based prosperity. NSF EPSCoR currently operates in 25 states – Alabama, Alaska, Arkansas, Delaware, Hawaii, Idaho, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Rhode Island, South Carolina, South Dakota, Tennessee, Vermont, West Virginia, and Wyoming – and in the Commonwealth of Puerto Rico and the Territory of the Virgin Islands.

EPSCoR goals and objectives are strongly aligned with major actions recommended recently by the National Academies' Committee on Prospering in the Global Economy of the 21st Century. Programmatic objectives are designed to stimulate further scientific and engineering prowess in the 27 EPSCoR jurisdictions. These jurisdictions have significant unused potential for contributing to the Nation's technology-based discovery, innovation, and productivity.

Approximately 27 percent of the funds requested will be available for new research grants. New funds will also support workshops and other outreach and capacity building activities. The remainder will go to continuing commitments made in previous years.

To pursue its goals and objectives, EPSCoR will employ a portfolio of three complementary strategies:

Research Infrastructure Improvement (RII) Grants – With an increase of $2.0 million over the FY 2008 Estimate, funding for RII will total $76.0 million. Research Infrastructure Improvement Grants are of two types. ***RII Track 1*** grants are awards of up to $15.0 million for up to 60 months, made to individual jurisdictions, to support infrastructure improvements in areas selected by the jurisdiction's EPSCoR governing committee as having the best potential to improve future research and development competitiveness. ***RII Track 2*** grants are awards of up to $2.0 million for up to 36 months, made to consortia of EPSCoR jurisdictions, to support innovation-enabling cyberinfrastructure of regional, thematic, or technological importance. Successful RII awards will build the core strength and capacity needed to develop both independent and collaborative methods for the solution of research and education problems having regional and national import. Activities supported through RII awards are expected to facilitate knowledge generation leading to economic development and to promote development of a diverse, well-prepared, internationally competent, and globally engaged STEM workforce necessary to sustain the Nation's competitive edge. These grants will enhance discovery and learning through use of cyber-infrastructure and other technologies, expand the scientific literacy of all citizens, and disseminate to them the importance of STEM research and education. The $2.0 million increase will support new RII Track II awards.

Co-Funding – Co-funding in FY 2009 will remain at the FY 2008 Estimate level of $36.0 million. Sustainable research competitiveness of EPSCoR jurisdictions across the Foundation requires increased funding of individual and group proposals in all NSF directorates and offices. To facilitate this, joint support may be provided for proposals that have been submitted directly to the NSF research and education directorates and offices, merit reviewed, and recommended for funding. Co-funding enables the EPSCoR program to collaboratively support cutting-edge research and education projects that have competed successfully through the merit review process within regular NSF programs and initiatives that would not otherwise be supported because of limited resources. This mechanism allows EPSCoR to build capacity at the research frontier in EPSCoR jurisdictions and to leverage its resources to more broadly integrate EPSCoR investigators and institutions into all Foundation programs.

Outreach – With an increase of $400,000 million over the FY 2008 Estimate, funding for Outreach activities will total $1.50 million. Financial support is provided for outreach visits by NSF staff to inform the EPSCoR research community about NSF priorities, programs, and policies and to more fully acquaint NSF staff from all directorates and offices with the research and development resources and potential residing within EPSCoR jurisdictions. The increase will support up to eight workshops that build jurisdictional and regional capacity in areas aligned with R&D activities selected by EPSCoR jurisdictions and NSF priority areas. Frequently, these outreach activities are workshop-based and, in all cases, build jurisdictional and regional capacity in essential dimensions of research competitiveness aligned with both state and NSF objectives.

Changes from FY 2008:

In FY 2009, the EPSCoR program expects to provide $76.0 million to fund a combination of new and continuing RII Track 1 and new RII Track 2 awards. This represents an increase of $2.0 million over the FY 2008 estimate and continues an ongoing commitment to ACI goals. Co-funding will be supported at the FY 2008 level of $36.0 million. Approximately $1.50 million, an increase of $400,000, will enable outreach activities, workshops, and conferences that build jurisdictional and regional research capacity.

Number of People Involved in EPSCoR Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	485	527	555
Other Professionals	134	152	155
Postdoctorates	42	45	47
Graduate Students	367	400	405
Undergraduate Students	364	402	411
Total Number of People	1,392	1,526	1,573

PERFORMANCE

The FY 2009 Request is aligned to reflect funding levels associated with NSF's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Integrative Activities
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actuals	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Discovery[1,2,3]	$115.20	$126.18	$143.49	$17.31	13.7%
Learning	9.19	9.19	13.56	4.37	47.6%
Research Infrastructure	94.32	96.14	118.04	21.90	22.8%
Stewardship	0.74	0.76	0.91	0.15	19.7%
Total, IA	$219.45	$232.27	$276.00	$43.73	18.8%

Totals may not add due to rounding.

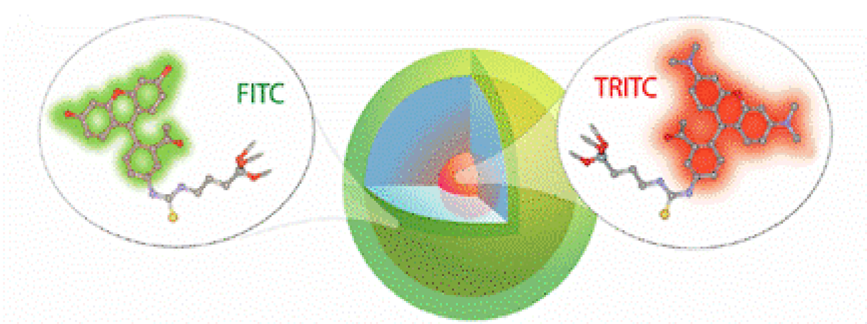
[1] Funding for Communicating Science Broadly is not included in numbers for FY 2007 and FY 2008. This effort was funded through Research and Related Activities Program Related Administration prior to FY 2009. See table on page IA-2 for detail.

[2] Funding for EPSCoR is shown for all years for comparability. EPSCoR was transferred from the Education and Human Resources appropriation to the Research and Related Activities appropriation in FY 2008.

[3] Funding for the Research and Development in the US (RaDiUS) database is reflected in FY 2007 Actuals and FY 2008 Estimates. FY 2009 funding is presented within Research.gov (see the Stewardship chapter).

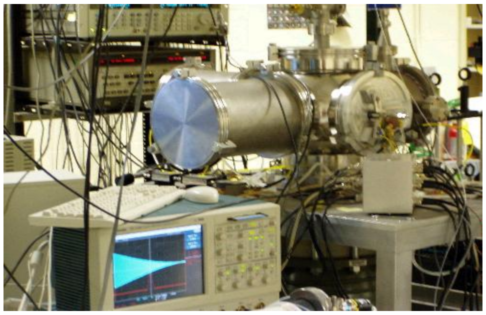
Recent Research Highlights

► **Moving Toward Single Particle Laboratories:** A research group in the Nanobiotechnology Center at Cornell University, a NSF Science and Technology Center, has developed a new design for labeling molecules with color-coded particles, increasing understanding of how diseases attack cells in the body and of the rapid growth of cancer cells in tumors. These engineered fluorescent silica nanoparticles can significantly enhance the brightness and stability of the dye molecules, and may be used to tag the precise location of a specific chemical compound in a living cell, such as in antibody recognition, as well as sense and report on the changing local chemical environment in a cell. (ENG/STC).



Schematic of the silica nanoparticle sensor architecture showing internal reference dye sequestered within the particle, and sensor dye distributed at the surface to maximize environmental exposure. *Credit: Andrew Burns, Prabuddha Sengupta, Barbara Baird, Ulrich Wiesner.*

► **Mission Impossible: An Innovative Microwave Spectrometer for Real Life Chemical Detection:** A University of Virginia research team has developed a new technique to identify chemical agents. This technique has dramatically reduced the time required for study of chemical structure in the gas phase, using a variety of analytical chemistry applications, such as breath analysis and detection of chemical warfare agents. The team also produced a microwave spectrometer that measures a much broader range of microwave frequencies than other spectrometers. The new microwave, known as "Chirped Pulse Fourier Transform Microwave," also allows the user to choose a desired sensitivity when obtaining measurements. (MPS/MRI).



Picture of the 11 GHz broadband Fourier transform microwave spectrometer (FTMW). *Credit: Photograph by Gordon G. Brown, Department of Chemistry, University of Virginia.*

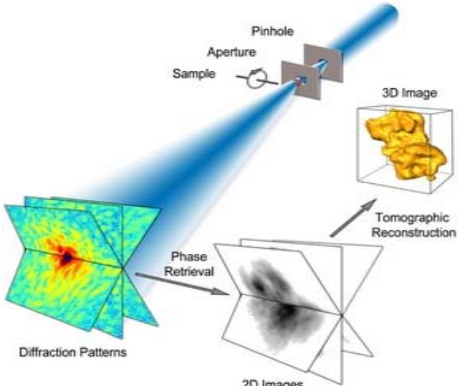


Diagram of X-ray imaging system for 3-D images. *Credit: UCLA.*

► **X-ray Vision in 3-D:** A new instrument produces three-dimensional images inside solid structures showing details 200,000 times smaller than the diameter of a human hair. Using one of the most powerful X-ray sources in the world, UCLA scientists have studied the interior structure of small particles of Gallium nitride – used to produce the blue light required for DVDs – to hold large quantities of high-definition video programming. They illustrated that an internal Gallium nitride and Gallium oxide structure partly controls the electronic properties of this material. The new imaging system produces 3-D images, shows fine structural details, maintains the integrity of the material under study, and works on material not in crystalline form. (MPS/MRI).

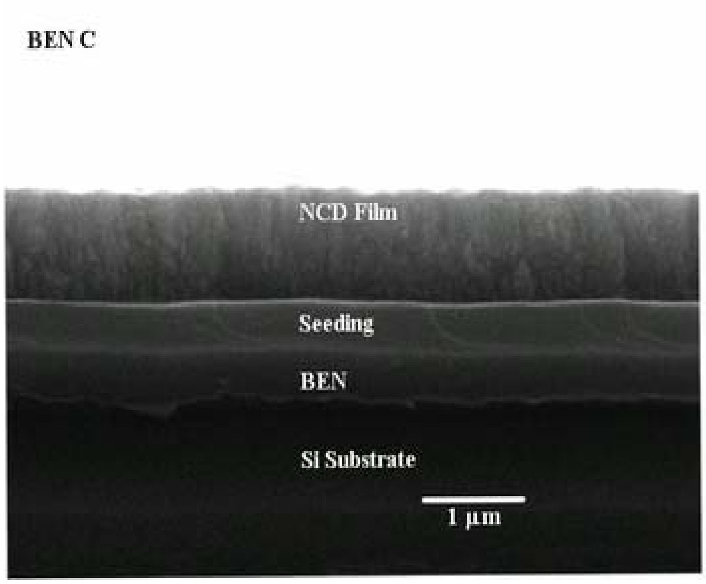
► **High-Performance Computing Infrastructure for Remote Work and Collaboration:** Major Research Instrumentation (MRI) provides a high performance computing infrastructure, resources, and training to a broad base of users, enabling researchers to view graphical output and engage in remote work and collaboration. With the help of University of Nebraska-Lincoln's PrairieFire supercomputer, researchers have generated many visualizations of the gold clusters' structure of nanocages. "Free-standing hollow cage structures," as they are also called, may carry useful atoms for medical or industrial purposes. This work was the first to combine quantum chemistry calculations with a powerful computerized search technique to identify previously unknown nano-sized structures and substances. Another team of scientists has developed a new way to rapidly identify cysteines, i.e., amino acids in proteins that have been found to play a role in heart disease and other diseases. (CISE/MRI).

This illustration shows a hollow nanocage made of 17 gold atoms. University of Nebraska-Lincoln researchers discovered the first free-standing hollow cage structures composed of clusters of pure gold atoms using the PrairieFire supercomputer. *Credit: University of Nebraska-Lincoln.*

Dr. Wayne Seames (center), SUNRISE Director and principal inventor of the UND biojet fuel process, observes as graduate students Autumn Dockter (left) and Swapnilkumar Gandhi (right) distill a test sample of biojet fuel. *Credit: Chuck Kimmerle, Photographer, Office of University Relations, University of North Dakota.*

► **Biojet Fuel from Crop Oils Takes Off:** With support from NSF's Experimental Program to Stimulate Competitive Research (EPSCoR), the SUNRISE research group of the University of North Dakota has developed an oilseed-based biojet fuel for aviation turbines and diesel engines that withstands cold temperatures and is more stable than traditional biodiesel fuels. The SUNRISE team is developing the technology to reduce the oil extraction cost specifically for biojet fuel application so that it is more cost effective than other fuels. SUNRISE also incorporates the research into chemistry and chemical engineering courses at the university, and educates the state's agricultural and financial communities and political leaders about biofuels and their potential economic impact. (OIA/EPSCoR).

► **Diamond Nanoparticles Improve Electrical Systems, Protective Coatings:** The University of Puerto Rico and the Center for Hierarchical Manufacturing at the University of Massachusetts, Amherst made a scientific and technological breakthrough that enables the direct integration of diamond nanoparticles into electronic components for widespread applications. These applications include protective coating for medical implants, environmental sensors, optical components exposed to harsh environments, and improved electrodes for electrical uses. The Diamond Nanotechnology Project was sponsored by NSF through EPSCoR. The University of Puerto Rico recently submitted to the U.S. Patent and Trademark Office a disclosure document for this development entitled, "Method to Synthesize Diamond on Polymers, Semiconductors, and Other Temperature-Sensitive Materials." (OIA/EPSCoR).



Scanning microscopy image showing the integration of nanocrystalline diamond (NCD) with semiconducting (Si) materials for electronic applications using bias-enhanced nucleation (BEN). *Credit: University of Puerto Rico.*

UNITED STATES ARCTIC RESEARCH COMMISSION $1,530,000

The FY 2009 Budget Request for the United States Arctic Research Commission (USARC) is $1.53 million, an increase of $60,000, or 4.1 percent, over the FY 2008 Estimate of $1.47 million.

U.S. Arctic Research Commission Funding

(Dollars in Millions)

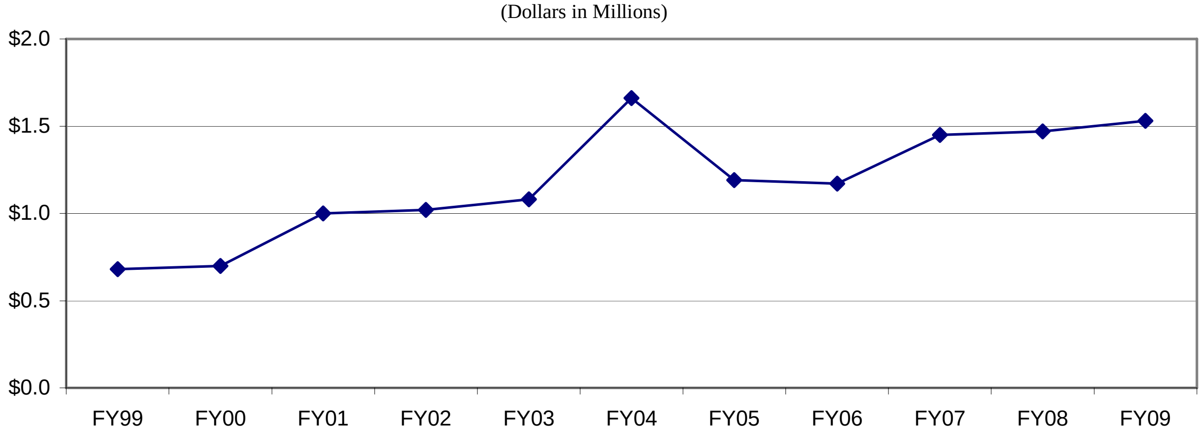
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
U.S. Arctic Research Commission (USARC)	$1.45	$1.47	$1.53	$0.06	4.1%

The USARC was created by the Arctic Research and Policy Act of 1984, (as amended, P. L. 101-609), to establish the national policy, priorities, and goals necessary to construct a federal program plan for basic and applied scientific research with respect to the Arctic, including natural resources and materials, physical, biological and health sciences, and social and behavioral sciences. This request provides funds to promote Arctic research, to recommend Arctic research policy, and to communicate research and policy recommendations to the President and the Congress, as well as supporting close collaboration with the National Science Foundation (NSF) as the lead agency responsible for implementing Arctic research policy and supporting cooperation and collaboration throughout the Federal Government. In addition, USARC gives guidance to the Interagency Arctic Research Policy Committee (IARPC) to develop national Arctic research projects and a five-year plan to implement those projects. USARC also supports interaction with Arctic residents, international Arctic research programs and organizations, and local institutions, including regional governments, in order to obtain the broadest possible view of Arctic research needs. USARC is an independent federal agency, funded through NSF's appropriations, specifically as an activity in the Research and Related Activities account.

The USARC is requesting an increase of $60,000 above the FY 2008 Estimate. Currently, there are five FTE funded at the USARC, with a total of seven FTE authorized.

U.S. Arctic Research Commission Funding

(Dollars in Millions)



Note: The increase in FY 2004 reflects a one-time recovery of $370,000.

EDUCATION AND HUMAN RESOURCES $790,410,000

The FY 2009 Budget Request for the Directorate for Education and Human Resources (EHR) is $790.41 million, an increase of $64.81 million, or 8.9 percent, over the FY 2008 Estimate of $725.60 million.

Education and Human Resources Funding
(Dollars in Millions)

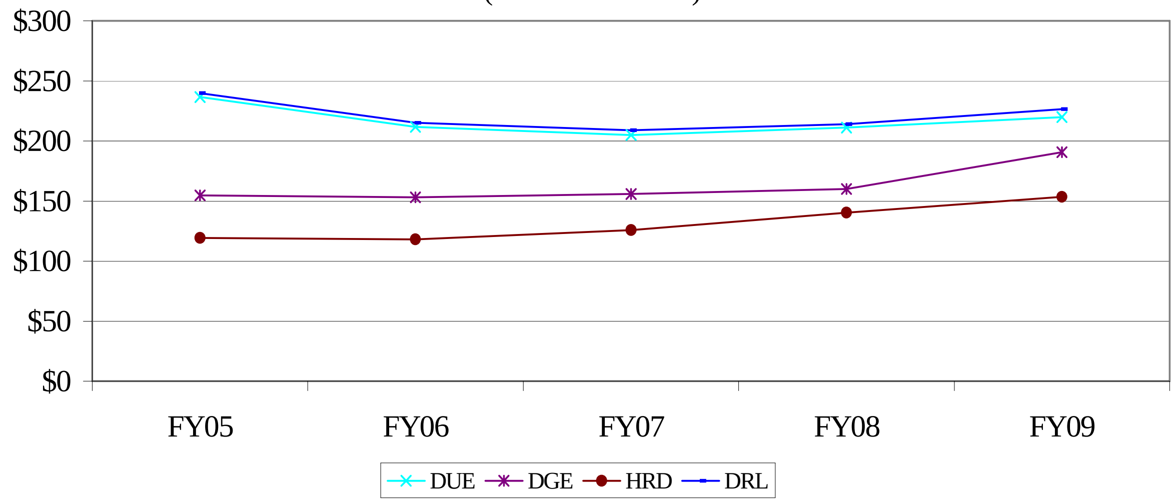
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Research on Learning in Formal and Informal Settings (DRL)	$208.99	$214.00	$226.50	$12.50	5.8%
Undergraduate Education (DUE)	204.96	211.05	219.83	8.78	4.2%
Graduate Education (DGE)	155.90	160.10	190.70	30.60	19.1%
Human Resource Development (HRD)	125.80	140.45	153.38	12.93	9.2%
Total, EHR[1]	$695.65	$725.60	$790.41	$64.81	8.9%

Totals may not add due to rounding.

[1] Excludes $145.94 million in FY 2007 obligations and an estimated $100.0 million in FY 2008 and FY 2009 receipts from H-1B Nonimmigrant Petitioner Fees.

NSF, in accordance with the NSF Act of 1950, is the principal federal agency charged with promoting science and engineering (S&E) education. In support of this mission, EHR promotes the development of a diverse and well-prepared workforce of scientists, technicians, engineers, mathematicians, and educators and a well-informed citizenry who have access to the ideas and tools of science and engineering. EHR supports education, research, and infrastructure development in all S&E disciplines. The purpose of these activities is to enhance the quality of life of all citizens and the health, prosperity, welfare, and security of the Nation and to build the science, technology, engineering, and mathematics (STEM) workforce of the 21st century.

EHR Subactivity Funding
(Dollars in Millions)



EDUCATION AND HUMAN RESOURCES

Appropriation Language

For necessary expenses in carrying out science and engineering education and human resources programs and activities pursuant to the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-1875), including services as authorized by 5 U.S.C. 3109, authorized travel, and rental of conference rooms in the District of Columbia, ~~$725,600,000,~~*$790,410,000*, to remain available until September 30, ~~2009.~~*2010. (Science Appropriations Act, 2008.)*

Education and Human Resources
FY 2009 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Carryover/ Recoveries	P.L. 110-161 Rescission	Total Resources	EPSCoR	Expired	Adj. Total Resources	Obligations Incurred/Est.
FY 2007 Appropriation	$796.69	$1.50	-	$798.19	-$102.11	-$0.33	$695.75	$695.65
FY 2008 Estimate	725.60	0.10	-0.10	725.60	-	-	725.60	725.60
FY 2009 Request	790.41	-	-	790.41	-	-	-	790.41
$ Change from FY 2008								$64.81
% Change from FY 2008								8.9%

Totals may not add due to rounding.

Adjustments to Base

In FY 2007, $102.11 million is being reported for EPSCoR in the Integrative Activities activity within the R&RA appropriation. The EHR FY 2009 Summary Statement table excludes EPSCoR from FY 2007 through FY 2009.

Explanation of Carryover

Within the Education and Human Resources (EHR) appropriation, a total of $99,331.14 was carried forward into FY 2008. This amount is rescinded, per P.L. 110-161.

RELEVANCE

NSF's EHR Directorate is the principal source of federal support for strengthening S&E education through education research and development (R&D). EHR programs support technological innovation to enhance economic competitiveness and new job growth, address the workforce needs of the Nation, and help ensure a scientifically literate population and a robust pool of talented experts.

EHR activities strengthen U.S. education at all levels to support continued U.S. economic and research preeminence. These activities are relevant to the following need expressed in the President's American Competitiveness Initiative (ACI):

> "Education is the gateway to opportunity and the foundation of a knowledge-based, innovation-driven economy. For the U.S. to maintain its global economic leadership, we must ensure a

continuous supply of highly trained mathematicians, scientists, engineers, technicians, and scientific support staff as well as a scientifically, technically, and numerically literate population."

EHR's programs seek to attract and retain people in STEM fields, increasing the Nation's ability to compete for and keep highly-skilled American workers. The programs do so by:

- promoting cooperation among academic institutions, industry, and government;
- encouraging the sharing of STEM resources and knowledge of critical skills needed by employers;
- supporting robust R&D on effective STEM education practices that increase retention of STEM students and teachers, and increase their content knowledge;
- broadening participation of underrepresented groups, geographic regions, and types of institutions in all S&E fields;
- providing scholarships and fellowships to graduate and undergraduate students in STEM fields; and
- recognizing outstanding efforts in STEM education and mentoring.

The FY 2009 Budget Request includes programs that support efforts to prepare a diverse, globally-engaged workforce and strengthen K-12 STEM education by enhancing our understanding of how students learn and applying that knowledge to train highly qualified teachers, develop effective curricular materials, and improve student learning.

To continue its national leadership in STEM research, policy and practice, in FY 2009 EHR will emphasize five thematic priorities: Broadening Participation to Improve Workforce Development; Enriching the Education of STEM Teachers; Furthering Public Understanding of Science and Advancing STEM Literacy; Promoting Cyber-enabled Learning Strategies to Enhance STEM Education; and Promoting Learning through Research and Evaluation. These thematic areas encourage the community to identify commonalities of purpose and characteristics that link across numerous programs. The thematic structure then emphasizes synergistic work among programs. The synergy will promote linkages and discussions among various stakeholder groups; advance our knowledge base in terms of breadth, depth and coverage; ensure a systematic response to national issues in STEM education; and help define NSF's strategic leadership in STEM education for the next several years.

Broadening Participation to Improve Workforce Development

A key component of this thematic priority is Innovation through Institutional Integration. Connectivity, integration, and synergy are keys to discovery and innovation. In both research and education, it is the forging of new links between ideas or methodologies that were previously disparate that paves the way for innovation. The innovation path can also be paved through new alliances and partnerships that integrate research and education, broaden participation, and attend to the critical educational junctures that often impede academic and career pursuits in STEM disciplines and thereby limit the capacity of the Nation's STEM workforce. These efforts will better enable higher education institutions to infuse these ingredients of a vibrant, 21st century STEM workforce into the fabric of their institutions.

This effort will also support greater intra-institutional and inter-institutional collaboration and synergy across NSF-funded projects from among selected flagship programs. These include those designed to broaden participation (e.g., LSAMP, including Bridge to the Doctorate; AGEP; CREST; ADVANCE; GSE; RDE), integrate research and education (e.g., IGERT, REU, including a new effort to expand REU to community colleges, CC-REU]), address critical junctures (MSP; Noyce; ATE; STEP), and increase the relevant knowledge base surrounding these issues (REESE). It will support student research experiences; adaptive learning experiences; cyber-enabled learning activities that promote integration and synergy; international experiences, and innovative curricula activities. This effort is expected to better integrate existing activities and lead to innovative institution-wide benefits.

Investments in this thematic priority support EHR's graduate education efforts. For example, the Bridge to the Doctorate component of LSAMP has enhanced its linkages with AGEP sites, providing opportunities for students to easily progress from undergraduate to graduate level STEM education. The ADVANCE program makes graduate education connections, as female talent from this level flows into faculty positions.

Enriching the Education of STEM Teachers

EHR proposes a new research and development thematic priority – *Teacher Education in STEM: Enriching Knowledge and Practice.* It is designed to advance knowledge and practice in the preparation of K-12 STEM teachers and to encompass the entire continuum – from pre-service education, to induction, to continuing professional development. The effort will help NSF meet the teacher preparation goals of the American Competitiveness Initiative (ACI), which stress the criticality of replacing the Nation's aging teacher corps, reducing attrition of STEM teachers, and broadening participation in STEM teaching.

This integrative effort is grounded in research and practice, builds on current knowledge while addressing critical issues and gaps in teacher education, and expands current and prior efforts to enable STEM teacher learning. It will address a number of objectives, including assuring that our Nation's K-12 teachers are:

- proficient in STEM concepts and topics;
- confident in their own grasp of STEM content;
- life-long learners of this content;
- aware of rapidly changing STEM disciplinary content;
- able to guide and assess STEM learning in age-appropriate ways;
- confident in the use of cyber-enabled tools;
- prepared to engage an increasingly diverse student population; and
- supported by STEM faculty, in collaboration with teacher education faculty and practitioners.

All of these objectives require a research knowledge base about STEM teacher learning that will serve as a foundation for improved models of teacher education.

A rigorous evaluation component, both at the project level as well as program-wide, will measure outcomes in terms of increased production of well-qualified teachers; knowledge and dissemination of proven strategies that contribute to this production; and evidence of a relationship between teacher education components and improved K-12 student learning. Research questions will address new areas of national importance concerning teacher preparation, induction, and professional development.

Furthering Public Understanding of Science and Advancing STEM Literacy

This thematic priority engages the full spectrum of research in STEM education, as well as translational research and development to bring science to learners of all ages and in all settings. It blends research at the frontiers of STEM with research at the frontiers of learning. STEM literacy is supported by improving STEM teaching and learning in the K-12 domain through cutting-edge educational research about learning, development of models and instructional tools for teachers and students, and the enrichment of teachers' learning of STEM content. Public understanding of science is advanced in informal learning settings through research-based and innovative exhibitions, films, television and radio series, cyber-enabled learning tools, citizen science programs, dialogues between scientists and the public, and youth and community initiatives about the content, processes and social impacts of STEM.

Promoting Cyber-enabled Learning Strategies to Enhance STEM Education

NSF has the distinctive capacity to link technological and computational innovators with domain scientists, learning specialists, and social/behavioral analysts for enhancing learning across the STEM disciplines broadly.

A distinctive feature of this thematic priority is the access it would give teachers, not only to their peers but to STEM specialists and to the knowledge about teaching and learning that those specialists continue to generate. In fact, through the National Science Distributed Learning (NSDL) NSF has gained significant experience in enhancing access of teachers to high quality teaching materials and resources. In terms of students in rural districts and low-income communities, they can gain access to advanced placement courses, often missing locally. The community of researchers has conveyed its strong commitment to a program of inquiry that examines the conditions under which cyberinfrastructure promotes STEM teaching and learning.

Key components of this thematic priority are the Federal Cyber Service: Scholarship for Service (SfS) program, NSDL, and the Innovative Technology Experiences for Students and Teachers (ITEST) program.

Promoting Learning through Research and Evaluation

Support for research and evaluation efforts will begin to enable us to develop NSF-wide evaluation efforts. Program evaluation, well established within EHR, is now being expanded Foundation-wide to cover all elements in NSF's STEM education portfolio. EHR will provide leadership – within NSF and across the STEM-centered federal agencies – to promote evaluations and to encourage programming that will improve both outcomes and opportunities for scalability. Such leadership requires the selection of evaluation methodologies that are appropriately matched to the question asked, the context of the activity, and the stage of development of the project and the world of practice that surrounds it. EHR will continue to adhere to rigorous evidence-based approaches, using multiple methods to evaluate our STEM education programs to determine the success and impacts of our investment and to advance the STEM education knowledge base. Our evaluation efforts will be tailored to the stage of the project, and will vary in duration, but frequently will be multi-year with annual reports on progress. We will continue to draw on the expertise of external evaluators in concert with that found within the agency. Likewise, we will continue to use the results of the programs to redirect, realign or consolidate activities, and/or enhance directions.

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, EHR……….……….…………………………………………...…...........…$725.60

Research on Learning in Formal and Informal Settings (DRL) +$12.50

FY 2009 funding emphasizes improving STEM teaching and learning in the K-12 domain through cutting-edge research and development. The FY 2009 Request includes funding increases of $8.50 million for the Discovery Research K-12 program; $3.0 million for Project and Program Evaluation; and $1.0 million for Informal Science Education. Support for Research and Evaluation on Education in Science and Engineering is equal to the FY 2008 Estimate.

Undergraduate Education (DUE) +$8.78

To further strengthen NSF's emphasis on increasing the quality and quantity of the science and engineering workforce, and the extent to which undergraduate students are well prepared for an increasingly technological global society, EHR will increase funding for most DUE programs.

The FY 2009 Request includes funding increases of $3.50 million for the Federal Cyber Service: Scholarship for Service program; $2.50 million for the NSF Math and Science Partnership program; $1.71 million for the Course, Curriculum, and Laboratory Improvement program; $800,000 for the Robert Noyce Teacher Scholarship Program; and $250,000 for the National Science Distributed Learning program (formerly the National STEM Education Digital Library program); and $20,000 for the Excellence Awards in Science & Engineering program. Funding for the Advanced Technological Education program and the STEM Talent Expansion Program is level with the FY 2008 Estimate.

Graduate Education (DGE) +$30.60

EHR funding for the Graduate Research Fellowship program will increase by $28.60 million over the FY 2008 Estimate, supporting an additional 700 graduate students. EHR funding increases by $2.0 million for the Graduate Teaching Fellows in K-12 Education program, supporting an additional 45 students. EHR funding for the Integrative Graduate Education and Research Traineeships program is level with FY 2008. All three of these programs also receive support through the Research and Related Activities appropriation.

Human Resource Development (HRD) +$12.93

The FY 2009 Request includes increases of $5.53 million for the Centers of Research Excellence in Science and Technology program; $2.0 million for the Louis Stokes Alliances for Minority Participation program; $1.40 million for the Alliances for Graduate Education and the Professoriate program; $1.25 million for the Research on Gender in Science and Engineering program; $1.0 million for the Historically Black Colleges and Universities Undergraduate Program; $750,000 for ADVANCE; $500,000 for the Research in Disabilities Education program; and $500,000 for the Tribal Colleges and Universities Program.

Subtotal, Changes +$64.81

FY 2009 Request, EHR ………………………………………………………………………........$790.41

Summary of Major Changes in Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, EHR……….……….……………………………………………...........…...$725.60

<u>Discovery</u> +$13.36

Discovery Research K-12 (DR-K12; +$8.50 million to $108.50 million).

DR-K12 investments will broaden participation in the S&E enterprise through the development of more effective tools and resources for teachers and students that will support inquiry-based classroom practices and a more intensive scientifically-based assessment of the efficacy of these resources. The increase in DR-K12 will address the broad recognition that teacher education in STEM is critical to the Nation’s future and ensure that teachers know how to guide and assess the learning of STEM content in age-appropriate ways, using available tools and resources. Of the DR-K12 increase, $3.70 million will support the new EHR thematic priority, Teacher Education in STEM: Enriching Knowledge and Practice (see fuller description above).

Centers of Research Excellence in Science and Technology (CREST; +$5.53 million to $30.53 million).

In support of the thematic priority of Broadening Participation to Improve Workforce

Development: Innovation through Institutional Integration, $2.10 million of CREST's increase will be directed to this effort. CREST's increase will be used to support an additional CREST award, 2 to 4 additional projects in the HBCU-RISE activity, up to 10 additional partnership supplements for the existing portfolio, and/or up to 12 additional SBIR/STTR diversity collaborations with industry partners co-funded with the Directorate for Engineering. Some combination of these award types is expected based on the most meritorious proposals received. This increase will support greater intra-institutional and inter-institutional collaboration and synergy including increased efforts designed to broaden participation.

The total funding change for the Discovery Strategic Outcome Goal also reflects a change in the Stewardship offset.

<u>Learning</u> +$48.81

Teacher Education ($10.0 million total).

Under the Teacher Education thematic priority FY 2009 increases include:

- *Math and Science Partnership (MSP) program (+$2.50 million overall; $1.0 million for Teacher Education).* The most recent study of the MSP program followed more than 300 schools participating in partnerships whose funding began during the program's second year. Results showed that students' performance on annual math and science assessments improved in almost every age group when their schools were involved in a program that linked K-12 teachers with their colleagues in higher education. The planned increase for MSP will address critical junctures in the educational experience through support for several additional partnerships, including new Teacher Institutes for the 21st century.

- *Robert Noyce Teacher Scholarship Program (Noyce; +$800,000 to $11.60 million).* Funding for Noyce will support a continued effort enabling more institutions to develop and implement programs to prepare STEM undergraduate majors and STEM professionals to become K-12 science and mathematics teachers.

- *Graduate Teaching Fellows in K-12 Education (GK-12; +$2.0 million to $49.0 million).* Funding for the Graduate Teaching Fellows in K-12 Education (GK-12) will support an additional 45 graduate fellows and up to 4 pilot projects linking GK-12 with community colleges in EPSCoR states.

- *Louis Stokes Alliances for Minority Participation (LSAMP; +$2.0 million to $42.50 million).* This will support up to 2 additional AMPs and/or up to 2 new sites for Bridge to Teaching awards. LSAMP expands participation of underrepresented minorities in STEM fields, including the field of STEM teaching.

- *Tribal Colleges and Universities Program (TCUP; +$500,000 to $13.35 million*). This increase will support up to two additional implementation awards which would include either a STEM Teachers of Excellence Education Project (STEEP) or a Phase II project from an institution that has already received a TCUP award. Additionally, the program will support a pilot effort to increase the participation in, and the scope of, individual undergraduate, placed-based research projects at several TCUP colleges. This design will be informed by the NSF Research Experiences for Undergraduates (REU) program, but it will target Tribal College and University students and STEM faculty working at their home institutions.

- An additional $3.70 million integral to this Teacher Education thematic priority is from the Discovery Research K-12 program (shown under Discovery). The National Science Distributed Learning (NSDL) program (shown under Research Infrastructure) and the Course, Curriculum and Laboratory Improvement program (shown below) will provide expertise to enhance the awards made relating to this thematic priority.

Broadening Participation to Improve Workforce Development: Innovation through Institutional Integration ($10.0 million total).

Program increases that contribute to the funding towards Innovation through Institutional Integration are as follows:

- *Centers of Research Excellence in Science and Technology (CREST; +$5.53 million; $2.10 million towards the Innovation through Institutional Integration effort).* The increase will support greater intra-institutional and inter-institutional collaboration and synergy including increased efforts designed to broaden participation. The full increase for CREST is described in the Discovery section above.

- *Historically Black College and Universities – Undergraduate Program (HBCU-UP; +$1.0 million to $31.0 million).* Additional HBCU-UP funds will support 4 to 8 new HBCU/STEM teacher development projects to increase the numbers of highly-prepared teachers through program tracks currently in place (Implementation, Targeted Infusion, and Education Research).

- *Alliances for Graduate Education and the Professoriate (AGEP; +$1.40 million to $16.75 million).* AGEP will support activities that focus on critical junctures into the professoriate including promoting national networking for the current AGEP community and increasing leveraging opportunities to advance careers of minority doctoral recipients.

- *Research on Gender in Science and Engineering (GSE; +$1.25 million to $11.50 million*). Additional funds will support two additional research-based innovation projects, which aim to inform practitioner communities about new advances in education research that enable more girls and young women to pursue STEM education and careers.

- *Research in Disabilities Education (RDE; +$500,000 to $6.50 million).* RDE will support an additional Focused Research Initiative award, which will use a quasi-experimental approach to investigate evidenced-based practices for preparing science and math educators to teach students with disabilities effectively.

- *ADVANCE. (+$750,000 to $1.25 million).* Funds will be used to forge relevant institutional linkages with other broadening participation efforts and to support value-added international activities to increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse STEM workforce.

The *Math and Science Partnership (MSP)* program will support the Innovation through Institutional Integration effort at a level of $1.50 million and the *Robert Noyce Teacher Scholarship Program (Noyce)* will provide $1.0 million for this effort.

Broadening Participation to Improve Workforce Development: Graduate Fellowships and Traineeships.

In addition to emphasizing broadening participation to improve workforce development, production of a robust scientific education community is an EHR priority; therefore, an increase in graduate education funding is central to this Request. Funding for the Graduate Research Fellowship program increases by $28.60 million in EHR, supporting an additional 700 fellows. The increase of $2.0 million for GK-12 is described above. Funding will remain equal to the FY 2008 Estimate for Integrative Graduate Education and Research Traineeships (IGERT).

Promoting Learning through Research and Evaluation.

- *Project and Program Evaluation (+$3.0 million to $10.0 million).* Additional funds will be used to support thematic STEM evaluation projects designed to enhance scientific workforce development and for collaborations that involve advanced learning technologies in science and engineering using cyberinfrastructure.

- *Course, Curriculum and Laboratory Improvement (CCLI; +$1.71 million to $39.21 million).* Additional funds in CCLI will support up to seven additional Phase 1 Projects allowing faculty members to pilot and evaluate new instructional and pedagogical approaches for improving the quality of undergraduate STEM education and the retention of students in these fields and to improve the quality of undergraduate education.

Promoting Cyber-enabled Learning Strategies to Enhance STEM Education.

- EHR's Federal Cyber Service: Scholarship for Service (SfS) program is increased by $3.50 million to $15.0 million to augment support for building a cadre of federal professionals with skills required to protect the Nation's critical information infrastructure.

- Fundamental to EHR's efforts on cyber-enabled learning are the National Science Distributed Learning (NSDL) program (shown under Research Infrastructure) and the Innovative Technology Experiences for Students and Teachers (ITEST) program (see p. EHR-26).

Furthering Public Understanding of Science and Advancing STEM Literacy.

- Informal Science Education *(ISE; +$1.0 million to $66.0 million).*
  ISE will expand its Communicating Research to Public Audiences program, by increasing award size to $100,000 and the number of awards to 15, to enable NSF-funded researchers to share their work with the public through exhibits, media, programs, and other deliverables developed in collaboration with informal education organizations such as science museums.

The total funding change for the Learning Strategic Outcome Goal also reflects a change in the Stewardship offset.

Research Infrastructure +$0.25

Promoting Cyber-enabled Learning Strategies to Enhance STEM Education

- The name of the National STEM Education Digital Library program is proposed to be changed to National Science Distributed Learning (NSDL) to better align with our strategic goals. NSDL funding increases by $250,000 to $16.50 million.

Stewardship +$2.39

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$64.81

FY 2009 Request, EHR ………..…………………………………………………………..........$790.41

NSF-WIDE INVESTMENTS

In FY 2009, the Directorate for Education and Human Resources will support research and education efforts related to broad, Foundation-wide investments in a number of areas, including the Administration's interagency R&D priorities.

EHR NSF-wide Investments

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Cyber-enabled Discovery and Innovation (CDI)	-	$3.00	$4.87	$1.87	62.3%
Cyberinfrastructure	17.74	16.25	16.50	0.25	1.5%
International Polar Year	2.45	2.00	-	-2.00	-100.0%
Mathematical Sciences	1.15	-	-	-	N/A
National Nanotechnology Initiative	3.27	3.10	3.10	-	-
Networking and Information Technology R&D	3.91	9.00	9.50	0.50	5.6%

Cyber-enabled Discovery and Innovation (CDI): EHR's CDI support totals $4.87 million, an increase of $1.87 million, to study the impact of information technology on educational practice, new approaches to using technology in education, application and adaptation of technologies to promote learning, the effects of technology on learning.

Cyberinfrastructure (CI): EHR's Cyberinfrastructure support totals $16.50 million, an increase of $250,000, and funds the National Science Distributed Learning program, an online network of learning environments and resources for STEM education at all levels in both formal and informal settings.

International Polar Year (IPY): With the conclusion of IPY in March 2009, key components of this investment will be retained for core programs.

Mathematical Sciences: With the conclusion of this priority area in FY 2007, key components of this investment will be retained for core programs.

National Nanotechnology Initiative (NNI): FY 2009 NNI support totals $3.10 million, the same as the FY 2008 Estimate. It will provide continuing support for nanoscience education activities.

Networking and Information Technology Research and Development (NITRD): FY 2009 support for NITRD totals $9.50 million, an increase of $500,000. This provides continuing support for information technology education activities and for the Cyber-enabled Discovery and Innovation investment.

Additional detail may be found in the NSF-wide Investment chapter.

QUALITY

EHR maximizes the quality of the research and education it supports through the use of a competitive, merit-based review process. Project evaluation is required, with projects reporting their progress and impact through annual and final reports to NSF. In addition, external program evaluations are conducted for EHR-managed activities.

To ensure the highest quality in processing and recommending proposals for awards, EHR convenes Committees of Visitors, composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. In FY 2007 COVs were held for the following programs: Scholarship for Service/Cybercorps, Historically Black Colleges and Universities – Undergraduate program, Tribal Colleges and Universities program, Teacher Professional Continuum, Louis Stokes Alliances for Minority Participation, Alliances for Graduate Education and the Professoriate, and Centers of Research Excellence in Science and Technology.

In FY 2008 COVs are planned for Graduate Teaching Fellowships in K-12 Education, Integrative Graduate Education and Research Traineeships, Informal Science Education, Information Technology Experiences for Students and Teachers, Math and Science Partnership, National STEM Education Digital Library, and the Robert Noyce Scholarship Program. In FY 2009 COVs are planned for the following programs: Research in Disabilities Education, Research on Gender in Science and Engineering, Graduate Research Fellowship, Research and Evaluation on Education in Science and Engineering, Science Technology, Engineering and Mathematics Talent Expansion Program, Course, Curriculum and Laboratory Improvement, and Advanced Technological Education.

The Directorate also receives advice from the Education and Human Resources Advisory Committee (EHRAC) on such issues as: the mission, programs, and goals that can best serve the scientific community; how EHR can promote quality graduate and undergraduate education in S&E; and priority investment areas in S&E education research. The EHRAC meets twice a year and members represent a cross section of S&E disciplines; a cross section of institutions including industry; broad geographic representation; and balanced representation of women, underrepresented minorities, and persons with disabilities.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with NSF's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Directorate for Education and Human Resources
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Discovery	$157.86	$164.35	$177.71	$13.36	8.1%
Learning	513.38	536.07	585.01	48.81	9.1%
Research Infrastructure	17.18	15.74	15.86	0.25	1.6%
Stewardship	7.24	9.44	11.83	2.39	25.3%
Total, EHR	$695.65	$725.60	$790.41	$64.81	8.9%

Totals may not add due to rounding.

Project and Program Evaluation

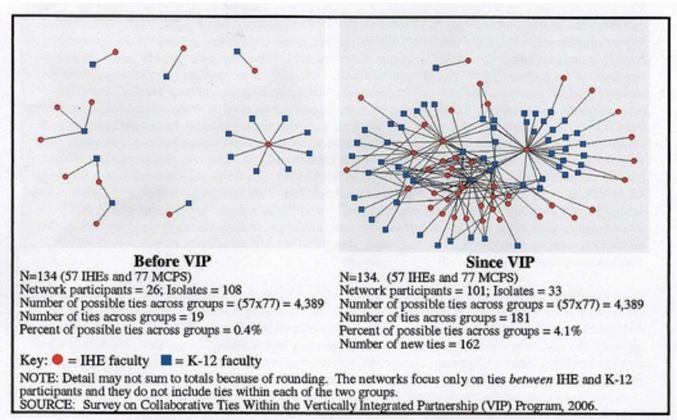
In 1992, performance monitoring and evaluation of education programs in EHR became a requirement. Since that time, EHR has conducted program evaluations of over 25 STEM education programs. Beginning in 2005, EHR required that every proposed project include an evaluation plan at the time of the proposal submission.

EHR programs make up a significant portion of the STEM education inventory prepared by the Academic Competitiveness Council (ACC). EHR programs increase American competitiveness in the global economy and support NSF's underlying strategy of integration of research and education. EHR's evaluation efforts strive to assess STEM education programs for improvement and effectiveness and facilitate policy decision-making in accordance with federal reporting requirements.

Across the Foundation, STEM education programs have broad goals, and hence represent the complexity of STEM education. The complexity and different stages of development of the projects require a mix of methods, if we are to optimize our understanding of program effectiveness. Program evaluation, well established within EHR, is now being expanded Foundation-wide to cover all elements in NSF's STEM education portfolio. This is evident in efforts that range from requirements for periodic review of project activities and cross-site analyses to those that expect qualitative and quantitative evidence of a program's success.

Recent Research Highlights

Broadening Participation to Improve Workforce Development



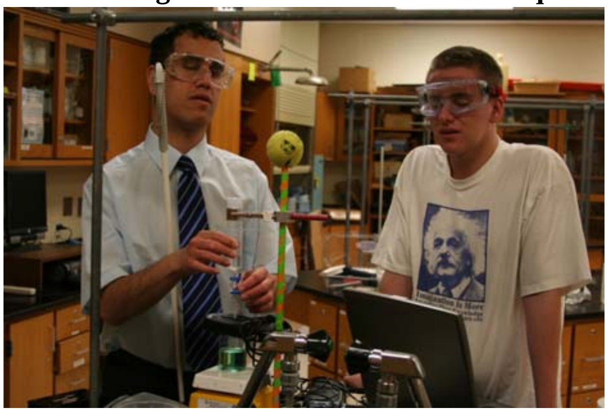
A network diagram, related to sharing new inquiry science teaching strategies or materials, demonstrates the increased density of vertical connections between K-12 teachers and faculty. *Credit: Vertically Integrated Partnerships K-16.*

► **Increasing Collaboration Improves Math, Science Instruction:** NSF's Math and Science Partnerships enable innovative collaboration between higher education and K-12 math and science faculty. Five years into the program, new collaborations are having a positive impact on student learning. The Vertically Integrated Partnerships project aims to foster collaboration among participating K-12 teachers in Montgomery County, Maryland public schools, and higher education faculty at the University of Maryland. An analysis of the evolving structure found an increase in such collaboration. The Partnership for Reform in Science and Mathematics (PRISM), a comprehensive project uniting state, university, and district entities, uses learning communities to improve the quality of science and mathematics teaching in Georgia. Teachers who participated in such communities reported greater emphasis on standards-based teaching than other teachers. (DUE/MSP)

► **Building Girls' Interest in Technology**: An after-school and summer program to encourage middle school girls to pursue careers in computers and information technology (IT) has shown remarkable success in sparking interest and challenging stereotypes. "Girls Creating Games" was funded by NSF to increase the number of women and girls in IT education and the workforce. The program aims to build girls' interest, skills, confidence, and fluency in IT through activities such as computer game design, collaborative computer programming, and working with adult female mentors. Based on pre- and post-test measures, participants reported significant increases in computer capabilities and independent problem solving skills related to IT. Findings also suggest that actively involving middle school girls in computer programming and IT processes can serve to mitigate the negative impacts stereotypes might have on girls' motivations to pursue interests and careers in STEM. The data collected from this program have made contributions to the understanding of how IT fluency can be measured, how to support pair programming, how girls learn and problem-solve on the computer, and how to promote "intrepid exploration" to increase the likelihood that girls will become producers, not just users, of IT. (HRD)

A pair of animated, middle school girls that appear on the 'Girls Creating Games' website. *Credit: Jill Denner, Education, Training, and Research (ETR) Associates.*

► **Creating Effective Tools and Techniques for Visually Impaired Students in Chemistry:** The "Techniques and Tools to Enhance Blind and Visually Impaired Students Participation in High School Level and General Chemistry Laboratory Classes" project has developed devices and lab procedures that allow blind and visually impaired students to conduct general chemistry laboratory experiments without the aid of sighted assistants. With the support of NSF's Research in Disabilities Education (RDE) program the research team at Penn State's Independent Laboratory Access for the Blind project (ILAB) has produced several devices for conducting chemistry experiments including a hand-held, submersible audible light sensor that fits in a test tube and converts the light intensity to an audible signal. They also created an inexpensive portable color recognizer to detect color of a substance in a beaker. The ILAB team has also been working with industry partners, including the Vernier Software and Technology Company, to make commonly used scientific software accessible to blind students who use speech output systems when independently conducting chemistry experiments. These science lab tools have been used by students at the Indiana State School for the Blind and at the Hopewell Valley Central High School, in Pennington, NJ. (HRD)



Blind students independently conduct a chemistry experiment. *Credit: Reprinted with permission from C&EN Copyright 2007 American Chemical Society. Photograph by Linda Wang.*

► **Graduate Research Fellow Links Basic Research with Innovative Entrepreneurship:** NSF Graduate Research Fellow Geoff Benton is linking his quest for new knowledge and his entrepreneurial interests to a career that involves technology transfer from academia to industry. In addition to his work on the basic science of mammalian cancer genes, he is working with Professor Thea Tlsty at the University of California at San Francisco. Geoff has been studying the effects of a tumor suppressing gene, p16, on the ability of cells to renew themselves. Last year, Geoff discovered new metabolic changes caused by the loss of p16 in human cells, thereby demonstrating a unique interaction between tumor suppressor genes and metabolism. Geoff and a fellow student also developed and launched JeffsBench.com, a social networking tool for the scientific community that improves communication and collaboration among graduate and post-doc researchers. (DGE)

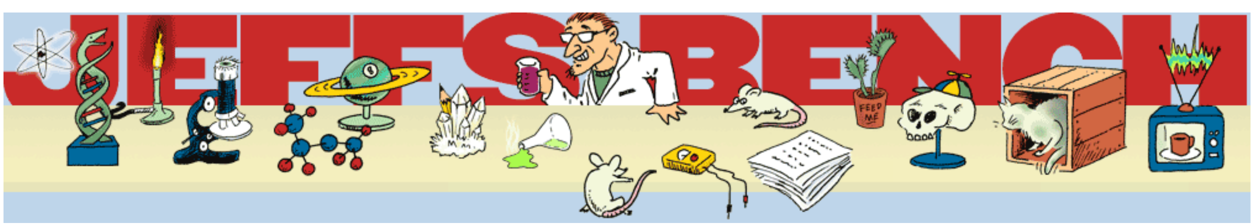


Image from social networking online tool for the scientific community that improves communication and collaboration among graduate and post-doc researchers. *Credit: Geoff Benton*.

Enriching the Education of STEM Teachers

► **Noyce Scholars Prepared to Teach in High-Need Schools:** The Robert Noyce Teacher Scholarship program at California State University, Fresno has recruited 63 new math and science teachers to teach in high-need school districts in California's Central Valley. Noyce scholars are placed in a high-need school science or mathematics classroom under the guidance of a selected mentor teacher and spend six to 10 hours per week as a teaching assistant. This experience affords Noyce Scholars a chance to develop classroom "survival skills" early on and to experience a wide range of activities associated with the teaching profession well before their student teaching semester. The program includes workshops taught by college faculty and expert K-12 teachers. Noyce Scholars have an opportunity to participate in cutting edge research through summer internships in Department of Energy laboratories. They also participate in professional development activities offered to area science and math teachers. Sixty five percent of the CSU Fresno Noyce Scholars are from underrepresented populations. The Scholars are continuing to teach in high need school settings beyond the required commitment. (DUE)

Samuel Saldivar, Noyce Scholar undergraduate from California State University, Fresno, participates in mathematics lesson study with math teachers and other Noyce Scholars while serving as a teaching assistant in Sanger Unified School District through the CSU-Noyce early field experience program. *Credit: David Andrews.*

► **Science Hits the Road:** Three projects in NSF's Graduate Teaching Fellows in K-12 Education (GK-12) program have together reached thousands of students. Rutgers University launched a 40-foot mobile laboratory bringing graduate students to deliver hands-on science to 14 middle schools and communities around New Jersey. Popular lessons focus on volcanoes, DNA and forensics. The Florida Institute of Technology's project highlights ocean sciences. A 35-foot mobile laboratory for high school students in Brevard County supports hands-on learning with multiple work stations and equipment including microscopes, GPS systems, and a weather station. The project at the University of Puerto Rico (Mayaguez) brings science to K-12 students through the "Science On Wheels" program, in which graduate fellows travel to schools and field sites to work with teachers and students. (DGE)

Graduate Fellows Ian Saginor and Marie Montes-Matias assist students with an activity on pressure and its role in volcanoes in Rutgers University's mobile laboratory. *Credit: GK-12/Rutgers University.*

Furthering Public Understanding of Science and Advancing STEM Literacy

► **Public Gets Science Buzz in Real Time**: The Science Museum of Minnesota's "Science Buzz" interactive Web site (http://dev.smm.org/buzz/) helps address the science literacy gap by blending up-to-the-minute science news and the latest Web technologies with science museum interactive and interpretive exhibits. Using an RSS feed, an open-source content management system and other technologies, Science Buzz allows visitors not only to learn about science, but to ask scientists questions, respond to polls on science-related issues, and post blog entries. Science Buzz can base new content

Museum visitor sending a "post card" with his photo and a link to the Science Buzz web site to a friend by e-mail. *Credit: Science Museum of Minnesota.*

on user feedback and enrich users' experience by linking them with news media, resources, and experts. This transformative project demonstrates new ways in which scientists can reach across formal and informal settings and convey to the public the processes whereby scientific research unfolds. (DRL)

Promoting Cyber-enabled Learning Strategies to Enhance STEM Education

Happy graduates of Scholarship for Service supported students from the master of science in security informatics program at the Johns Hopkins University. *Credit: Gerald Masson.*

► **Johns Hopkins Information Security Institute:** The Johns Hopkins University Information Security Institute will have awarded 32 master of science in security informatics (MSSI) degrees to NSF Scholarship for Service (SFS) scholarship recipients as of May 2008. Additionally, six of these students will have completed an innovative dual masters program, developed with the support of an SFS capacity building grant, which lets students complete the requirements of the degree and another master of science degree program within two academic years. Upon completion of the degree program, SFS scholarship recipients have been placed into positions at the National Security Agency, Treasury Department, National Institute of Standards and Technology, National Aeronautics and Space Administration, Internal Revenue Service, Central Intelligence Agency, Federal Reserve Board, Lawrence Livermore Labs, Hopkins Applied Physics Lab, Executive Office for U.S. Attorneys, U.S. Army, Army Space and Terrestrial Communication Directorate, and the Department of Health and Human Services. (DUE)

Other Performance Indicators

The table below shows the number of people that participate in EHR funded activities.

Number of People Involved in EHR Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	5,904	5,950	6,000
Other Professionals	2,601	2,600	2,700
Postdoctorates	302	310	315
Graduate Students	6,806	6,900	7,700
Undergraduate Students	3,918	4,000	4,100
K-12 Students	10,800	12,000	12,500
K-12 Teachers	60,700	62,000	63,500
Total Number of People	91,031	93,760	96,815

In addition, it is estimated that in FY 2007 EHR programs directly impacted more than 400,000 K-12 teachers and more than 16 million K-12 students nationwide. Examples of direct impact include use of EHR-funded instructional materials by teachers and students, and students that benefit from teacher attendance at EHR-supported workshops and training seminars.

RESEARCH ON LEARNING IN FORMAL AND INFORMAL SETTINGS — $226,500,000

The FY 2009 Budget Request for the Division of Research on Learning in Formal and Informal Settings (DRL) is $226.50 million, an increase of $12.50 million, or 5.8 percent, over the FY 2008 Estimate of $214.0 million.

Research on Learning in Formal and Informal Settings Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Research on Learning in Formal and Informal Settings	**$208.99**	**$214.00**	**$226.50**	**$12.50**	**5.8%**
Major Components:					
Discovery Research K-12	98.16	100.00	108.50	8.50	8.5%
Informal Science Education (ISE)	63.93	65.00	66.00	1.00	1.5%
Research and Evaluation on Education in S&E	41.89	42.00	42.00	-	-
Project and Program Evaluation	5.01	7.00	10.00	3.00	42.9%

About DRL:

The Division of Research on Learning in Formal and Informal Settings advances the coherent integration of STEM education research, development, evaluation, and synthesis activities. DRL focuses on the full spectrum of basic and applied research in STEM education in both formal and informal settings, at all levels. There is a strong emphasis on improving STEM teaching and learning in the K-12 domain through cutting-edge development and applied research.

DRL programs provide national leadership for advancing discovery and innovation at the frontiers of STEM teaching and learning in the K-12, undergraduate, and graduate settings, and in lifelong learning. The Division is committed to improving STEM learning, particularly in K-12 schools, and in informal education environments; advancing equity and participation in STEM for all; and integrating research and practice. DRL research and development addresses significant educational challenges, including preparing and supporting highly qualified teachers in the STEM disciplines with strong, integrated knowledge of the disciplines and of pedagogy. DRL sponsors the design of research-based K-12 learning tools, resources, and materials that embody high expectations for all students, and studies and evaluations of their strategic implementation and impact. Research in DRL addresses issues of STEM learning at the undergraduate and graduate levels, and across the lifespan. The Division is concerned with expanding the number of students interested in and educated for careers in STEM fields and ensuring that the citizenry has the opportunities to continue their learning of science in a variety of exciting and compelling venues.

DRL Priorities for FY 2009:

DRL has leadership within EHR for two of the five thematic priorities in FY 2009: Public Understanding and Research and Evaluation. The increased funding for evaluation aims to bring the expertise within the division to improvements in evaluation. DR-K12 is a significant contributor to Enriching the Education of STEM Teachers priority; ISE has a national leadership role in Furthering Public Understanding of Science and Advancing STEM Literacy; and DRL's Project and Program Evaluation expertise is a keystone to EHR's Promoting Learning through Research and Evaluation priority.

- **Discovery Research K-12** (DR-K12) supports applied research and innovation aimed at improving STEM education at the K-12 level. The research and evaluation in DR-K12 projects focus on K-12 instructional resources and tools developed with NSF funding, and includes development, implementation, and evaluation activities conducted in K-12 settings. Discovery research addresses problems generated by practice and implementation and is focused on targeted, strategic interventions. The program allows for continued efforts to develop and evaluate cutting-edge materials in K-12 STEM.

- **Informal Science Education** (ISE) supports the design and development of experiences that encourage learning in informal settings and that promote public engagement with, and understanding of, the STEM disciplines. ISE projects advance leading-edge, state-of-the art efforts to expand the venues and opportunities for science learning, for all learners at all ages. Projects that strengthen infrastructure, engage underserved audiences, involve the public, and introduce innovative uses of technologies will be of highest priority.

- **Project and Program Evaluation** is a strong focus of EHR/DRL. Emphases include planning and oversight for third-party evaluations of EHR programs and thematic STEM evaluation studies; providing evaluation technical assistance throughout EHR and NSF as well as providing training opportunities and tools to build capacity in the field. EHR's evaluation team coordinates data collection efforts for performance monitoring and responding to GPRA and other federal reporting requirements; disseminates broader information and evaluation findings to various stakeholders; and addresses directorate-wide knowledge management concerns for improved productivity.

- **Research and Evaluation on Education in Science and Engineering** (REESE) supports basic and applied research and evaluation that enhances understanding of STEM learning and teaching. The program seeks proposals for syntheses of research and evaluation in order to accumulate knowledge, identify gaps, and integrate across literatures and disciplines. REESE also supports empirical studies that advance discovery and innovation at the frontiers of STEM learning. The REESE program spans formal and informal education and all stages of learners.

Changes from FY 2008:

- The FY 2009 Request for **DR-K12** is $108.50 million, an increase of $8.50 million over the FY 2008 Estimate of $100.0 million. As part of the new EHR investment, *Teacher Education in STEM: Enriching Knowledge and Practice,* DR-K12 investments will broaden participation in the S&E enterprise through the development of more effective tools and resources for teachers and students, which will support inquiry-based classroom practices and a more intensive scientifically-based assessment of the efficacy of these resources. The increase in DR-K12 will address the broad recognition that teacher education in STEM is critical to the Nation's future and ensure that teachers know how to guide and assess the learning of STEM content in age-appropriate ways, using available tools and resources.

- The FY 2009 Request for **Project and Program Evaluation** is $10.0 million, an increase of $3.0 million over the FY 2008 Estimate of $7.0 million. These additional funds will be used to support thematic STEM evaluation projects designed to enhance science and engineering workforce development and for collaborations with advanced learning technologies in science and engineering using cyberinfrastructure.

- The FY 2009 Request for **ISE** is $66.0 million, an increase of $1.0 million over the FY 2008 Estimate of $65.0 million. This will result in 1-3 additional awards in FY 2009.

UNDERGRADUATE EDUCATION $219,830,000

The FY 2009 Budget Request for the Division of Undergraduate Education (DUE) is $219.83 million, an increase of $8.78 million, or 4.2 percent, over the FY 2008 Estimate of $211.05 million.

Undergraduate Education Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Curriculum, Laboratory and Instructional Development[1]	$84.41	$83.45	$85.41	$1.96	2.3%
Workforce Development[1]	74.60	79.10	83.42	4.32	5.5%
Math and Science Partnership	45.95	48.50	51.00	2.50	5.2%
Total, DUE	**$204.96**	**$211.05**	**$219.83**	**$8.78**	**4.2%**
Selected Programs:					
Advanced Technological Education	50.58	51.62	51.62	-	-
Course, Curriculum, and Laboratory Improvement	37.78	37.50	39.21	1.71	4.6%
Robert Noyce Teacher Scholarship Program	10.30	10.80	11.60	0.80	7.4%
Scholarship for Service	11.36	11.50	15.00	3.50	30.4%
STEM Talent Expansion Program	28.90	29.70	29.70	-	-

Totals may not add due to rounding.
1/ The Robert Noyce Teacher Scholarship program is included in the Workforce Development line. NSF proposes to move this program from the Curriculum, Laboratory, and Instructional Development line as of FY 2008 in order to better align with the program's purpose.

About DUE:

DUE is the NSF focal point for transforming undergraduate STEM education to meet the needs of the 21st century. DUE's objective is to increase the quality and quantity of the science and engineering workforce, and the extent to which all undergraduate students are well prepared for an increasingly technological global society. DUE programs emphasize innovation and ongoing improvement in curricula, teaching procedures, and laboratories, so that the next generation is always learning by using the tools and methods of inquiry that working professionals use. Collaborations among institutions, and between higher education, industry, and the K-12 sector are encouraged. So that best practices penetrate deeply into the community, DUE grants provide for faculty development, support for new instructional materials, the reform of courses, laboratories, and curricula, and assessment of outcomes.

DUE programs are funded through three budget lines. Included in the Curriculum, Laboratory and Instructional Development line are the Course, Curriculum, and Laboratory Improvement program, the STEM Talent Expansion Program, and the National Science Distributed Learning program. Workforce Development includes Advanced Technological Education, Federal Cyber Service: Scholarship for Service, the Robert Noyce Teacher Scholarship Program, and Excellence Awards in Science & Engineering. The Math and Science Partnership program is funded through its own budget line.

DUE Priorities for FY 2009:

DUE leads EHR's efforts in teacher education and cyber-infrastructure for learning. DUE contributes significantly, too, to the broadening of participation and institutional integration. Its role in teacher education will be enhanced through increases in the MSP and Noyce programs. DUE's contributions to the cyber world is most evident in the NSDL program – a program with clear implications for teacher education. With reference to the broadening of participation, DUE grantees do so through the ATE program (targeted to community colleges) and the EASE awards (especially those for mentoring). The Federal Cyber Service: Scholarship for Service program addresses the priority of Promoting Cyber-enabled Learning Strategies to Enhance STEM Education.

- The **Federal Cyber Service: Scholarship for Service** (SfS) program, which is relevant to the Comprehensive National Cybersecurity Initiative, builds a cadre of federal professionals with skills required to protect the Nation's critical information infrastructure. Scholarships provide full tuition, fees, and stipends in exchange for service in federal agencies after graduation.

- The **Math and Science Partnership** (MSP) at NSF is a research and development effort to build capacity and integrate the work of higher education, especially its STEM disciplinary faculty, with that of K-12 to strengthen and reform science and mathematics education. MSP will continue to coordinate its efforts with other education programs at NSF, the Department of Education, and in states.

- The **Course, Curriculum, and Laboratory Improvement** (CCLI) program funds development of new learning materials, faculty expertise, and assessment and evaluation. CCLI supports innovative educators who build the STEM workforce and keeps teachers aligned with change in capability of STEM disciplines.

- The **Robert Noyce Teacher Scholarship Program** encourages talented STEM undergraduate students and professionals to become K-12 mathematics and science teachers through scholarships and stipends. Projects help recipients obtain certification and become STEM teachers in high-need K-12 schools.

- The **National Science Distributed Learning** (NSDL) program provides resources for STEM education at all levels. NSDL funds projects that provide stewardship for the content and services needed by major communities of learners.

Changes from FY 2008:

- The FY 2009 Request for **CCLI** is $39.21 million, an increase of $1.71 million above the FY 2008 Estimate of $37.50 million. New funds will permit an increase in the success rate for this core program.

- The FY 2009 Request for **Noyce** is $11.60 million, an increase of $800,000 over FY 2008. Funding will support efforts to prepare STEM undergraduate majors and STEM professionals to become K-12 science and mathematics teachers.

- The FY 2009 Request for **NSDL** is $16.50 million, an increase of $250,000 over the FY 2008 Estimate and provides for continued stewardship.

- FY 2009 funding for **SfS** is increased by $3.50 million over the FY 2008 Estimate to $15.0 million, which will to support up to an additional nine cohorts of up to 10 students each.

- In FY 2009, funding for **EASE** is increased to $5.20 million, $20,000 above the FY 2008 Estimate.

- The FY 2009 Request for **MSP** is increased by $2.50 million over the FY 2008 Estimate to $51.0 million. Of this increase, $1.50 million supports the Innovation through Institutional Integration effort. The remaining $1.0 million support the Teacher Education thematic priority.

GRADUATE EDUCATION $190,700,000

The FY 2009 Budget Request for the Division of Graduate Education (DGE) is $190.70 million, an increase of $30.60 million, or 19.1 percent, over the FY 2008 Estimate of $160.10 million.

Graduate Education Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Graduate Education	**$155.90**	**$160.10**	**$190.70**	**$30.60**	**19.1%**
Major Components:					
Integrative Graduate Education and Research Traineeships (IGERT)	25.27	25.00	25.00	-	-
Graduate Research Fellowships (GRF)	86.08	88.10	116.70	28.60	32.5%
Graduate Teaching Fellows in K-12 Education (GK-12)	44.55	47.00	49.00	2.00	4.3%

About DGE:

DGE investments support graduate students and innovative graduate programs that prepare tomorrow's leaders in science and engineering. DGE funding for science, technology, engineering, and mathematics (STEM) graduate education supports the creation of a diverse STEM workforce to meet the needs of the Nation in the 21st century. DGE accomplishes this by providing fellowships and traineeships, by supporting innovations in STEM graduate education to prepare students for the challenges of the new century, and by building stronger links between higher education and K-12 education. These efforts help strengthen U.S. education at all levels and help ensure continued U.S. economic and research preeminence.

DGE meets its objectives through three graduate education programs: IGERT, GRF, and GK-12. Approximately 5,450 graduate fellowships and traineeships will be supported NSF-wide in FY 2009.

DGE Priorities for FY 2009:

- A significant increase is proposed for the **Graduate Research Fellowship** program, which strategically invests in intellectual capital, providing support to individuals who are pursuing graduate education. It prepares the most promising science, mathematics, and engineering students in the U.S. for a broad range of disciplinary and cross-disciplinary careers. It offers three years of financial support, which may be used by students over a five-year period, providing a flexible operational framework.

  Since 1952, over 43,000 U.S. students have received GRFs. In FY 2009 approximately 3,075 fellows will be supported, primarily with DGE funds. The Directorates for Engineering (ENG) and Computer and Information Science and Engineering (CISE) also provide support for the GRF program. Although at early stages of their careers, Fellows begin building distinguished records of accomplishment. GRF is widely recognized as a unique fellowship grant program because it supports the broad array of science and engineering disciplines across all fields as well as international research activity. In FY 2007, DGE received over 8,000 applications for its highly prestigious and competitive GRF awards, and was able to award approximately 900 fellowships.

- The **Graduate Teaching Fellows in K-12 Education** program supports fellowships and associated training that enable graduate students in NSF-supported STEM disciplines to acquire additional skills that will broadly prepare them for professional and scientific careers. Through interactions with teachers in K-12 schools, graduate students improve communication and teaching skills while enriching STEM instruction in these schools. Approximately 950 GK-12 fellows will be supported NSF-wide in FY 2009. Through collaboration with the Office of Cyberinfrastructure (OCI), GK-12 is developing opportunities for fellows to explore CI applications in research and education. Each year GK-12 receives more excellent proposals than can be funded. In the FY 2007 competition, the GK-12 program received 140 proposals, and made approximately 27 awards.

- EHR's funding for the **Integrative Graduate Education and Research Traineeship** program is level with the FY 2008 Estimate. IGERT is an NSF-wide program administered by DGE and is part of EHR's Innovation through Institutional Integration effort. IGERT prepares U.S. doctoral students to lead the Nation in advancing knowledge in emerging areas of research and to pursue successful careers in academia, industry, or the public sector. IGERT (institutional) awardees prepare doctoral students by integrating research and education in innovative ways that are tailored to the unique requirements of newly emerging interdisciplinary fields and new career options. IGERT campuses train students to be leading scientists and engineers in the 21st century, provide several trainees with international experiences, and focus on broadening participation. Approximately 1,425 IGERT trainees will be supported across NSF in FY 2009.

Each of the three major DGE programs recognizes the growing significance of the changing global environment for future scientists and is taking steps to bring more international emphasis and provide more opportunities for students to expand their knowledge of research and education in other nations and international issues affecting STEM careers.

Changes from FY 2008:

- The EHR FY 2009 Request for GRF is $116.70 million, an increase of $28.60 million over the FY 2008 Estimate. This increase will provide support for an additional 700 graduate students.

- The EHR FY 2009 request for GK-12 is $49.0 million, an increase of $2.0 million over the FY 2008 Estimate. This increase will allow NSF to fund 45 additional students.

HUMAN RESOURCE DEVELOPMENT $153,380,000

The FY 2009 Budget Request for the Division of Human Resource Development (HRD) is $153.38 million, an increase of $12.93 million, or 9.2 percent, over the FY 2008 Estimate of $140.45 million.

Human Resource Development Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Undergraduate/Graduate Student Support	$76.36	$83.35	$86.85	$3.50	4.2%
Research and Education Infrastructure	34.11	40.35	47.28	6.93	17.2%
Opportunies for Women and Persons with Disabilities	15.33	16.75	19.25	2.50	14.9%
Total, HRD	**$125.80**	**$140.45**	**$153.38**	**$12.93**	**9.2%**

Totals may not add due to rounding.

About HRD:

HRD supports programs and activities that enhance the quantity, quality, and diversity of individuals engaged in U.S. science, technology, engineering, and mathematics (STEM). HRD plays a central role in increasing opportunities in STEM education for individuals from historically underserved populations – particularly minorities, women, and persons with disabilities – as well as the educators, researchers, and institutions dedicated to serving these populations.

HRD programs are funded through three budget lines. Included in the Undergraduate/Graduate Student Support line are the Louis Stokes Alliances for Minority Participation program, the Tribal Colleges and Universities Program, and the Historically Black Colleges and Universities Undergraduate Program (HBCU-UP). Research and Education Infrastructure includes the Alliances for Graduate Education and the Professoriate and Centers of Research Excellence in Science and Technology programs. Included in the Opportunities for Women and Persons with Disabilities are the Research on Gender in Science and Engineering program, the Research in Disabilities Education program, and the ADVANCE program.

HRD Priorities for FY 2009:

HRD is central to EHR's thematic priority of Broadening Participation to Improve Workforce Development. The FY 2009 Request supports programs with a proven track record of broadening participation in the science and engineering workforce.

HRD is also a centerpiece in Innovation through Institutional Integration. The flagship programs in HRD that collaborate on this effort are LSAMP, AGEP, CREST, ADVANCE, the Research on Gender in Science and Engineering (GSE) program, and the Research in Disabilities Education (RDE) program. This effort will support student research experiences; adaptive learning experiences; cyber-enabled learning activities that promote integration and synergy; international experiences, and innovative curricula activities. This effort is expected to better integrate the existing activities and lead to innovative institution-wide benefits.

Significant contributions are expected from the HRD community in EHR's priority to enrich the education of STEM teachers. Through this new research and development investment, LSAMP and TCUP will work to advance knowledge and practice in the preparation of K-12 STEM teachers and to encompass the entire continuum – from pre-service education, to induction, to continuing professional development.

Changes from FY 2008:

- **CREST** funding for FY 2009 is $30.53 million, an increase of $5.53 million. This increase will support an additional CREST award, 2 to 4 additional projects in the HBCU-RISE activity, up to 10 additional partnership supplements for the existing portfolio, and/or up to 12 additional SBIR/STTR diversity collaborations with industry partners co-funded with the Directorate for Engineering. Some combination of these award types is expected based on the most meritorious proposals received.

- **LSAMP** funding for FY 2009 is $42.50 million, an increase of $2.0 million. This increase will support up to two additional AMPs and/or up to two new sites for Bridge to Teaching awards. These programs expand the participation of underrepresented minorities in STEM fields thereby strengthening the Nation's science and engineering workforce.

- **AGEP** funding for FY 2009 is $16.75 million, an increase of $1.40 million. This increase will support activities that focus on critical junctures into the professoriate such as funding auxiliary services to the current AGEP community to promote networking at a national level and significantly increase leveraging opportunities with respect to career progression of minority doctoral recipients.

- **GSE** funding for FY 2009 is $11.50 million, an increase of $1.25 million. Additional GSE funds will support two additional "diffusion of research-based innovation projects," which aim to inform practitioner communities about new advances in education research that enable more girls and young women to pursue STEM education and careers.

- **HBCU-UP** funding for FY 2009 is $31.0 million, an increase of $1.0 million. Additional HBCU-UP funds will support 4 to 8 new HBCU/STEM teacher development projects to increase the numbers and high-quality preparation of teachers, through program tracks currently in place (Implementation, Targeted Infusion, and Education Research).

- **ADVANCE** funding for FY 2009 is $1.25 million, an increase of $750,000. Funds will be used to forge relevant institutional linkages with other broadening participation efforts and to support value-added international activities to increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse STEM workforce.

- **RDE** funding for FY 2009 is $6.50 million, an increase of $500,000. This will support an additional Focused Research Initiative award, which will use a quasi-experimental approach to investigate evidenced-based practices preparing science and math educators to effectively teach students with disabilities.

- **TCUP** funding for FY 2009 is $13.35 million, an increase of $500,000. This increase will support up to two additional implementation awards which would include either a STEM Teachers of Excellence Education Project (STEEP) or a Phase II project from an institution that has already received a TCUP award. Additionally, the program will support a pilot effort to increase the participation in, and the scope of, individual undergraduate, placed-based research projects at several TCUP colleges.

H-1B NONIMMIGRANT PETITIONER FEES $100,000,000

The FY 2009 H-1B Nonimmigrant Petitioner Fees are projected to be $100.0 million, equivalent to the FY 2008 projection.

H-1B Nonimmigrant Petitioner Fees Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	Change over FY 2008 Estimate Amount	Percent
H-1B Nonimmigrant Petitioner Fees Funding	$145.90	$100.00	$100.00	-	-

Beginning in FY 1999, Title IV of the American Competitiveness and Workforce Improvement Act of 1998 (P.L. 105-277) established an H-1B Nonimmigrant Petitioner Account in the general fund of the U.S. Treasury for fees collected for each petition for alien nonimmigrant status. That law required that a prescribed percentage of funds in the account be made available to NSF for the following activities:

- **Computer Science, Engineering, and Mathematics Scholarships** (CSEMS). The program supported grants for scholarships to academically-talented, financially needy students pursuing associate, baccalaureate, or graduate degrees in computer science, computer technology, engineering, engineering technology, or mathematics. Grantee institutions awarded scholarships of up to $2,500 per year for two years to eligible students.

- **Grants for Mathematics, Engineering, or Science Enrichment Courses.** These funds provided opportunities to students for enrollment in year-round academic enrichment courses in mathematics, engineering, or science.

- **Systemic Reform Activities.** These funds supplemented the rural systemic reform efforts administered under the former Division of Educational System Reform (ESR).

In FY 2001, Public Law 106-311 increased the funds available by increasing the petitioner fees. Also, the American Competitiveness in the 21st Century Act (P.L. 106-313) amended P.L. 105-277 and changed the way petitioner fees were to be expended.

- The CSEMS activity continued under P.L. 106-313 with a prescribed percentage of H-1B receipts. The maximum scholarship duration was four years and the annual stipend was $3,125. Funds for this scholarship program totaled 59.5 percent of the total H-1B funding for NSF.

- Private-Public Partnerships in K-12. P.L. 106-313 directed the remaining 40.5 percent of receipts toward K-12 activities involving private-public partnerships in a range of areas such as materials development, student externships, and mathematics and science teacher professional development.

- Information Technology Experiences for Students and Teachers (ITEST) developed as a partnership activity in K-12 to increase opportunities for students and teachers to learn about, experience, and use information technologies within the context of STEM, including Information Technology (IT) courses.

In FY 2005, Public Law 108-447 reauthorized H-1B funding. NSF was provided with 40 percent of the total H-1B receipts collected. Thirty percent of H-1B receipts (75 percent of the receipts that NSF receives) are to be used for the Low-income Scholarship Program. Ten percent of receipts (25 percent of the receipts that NSF receives) are designated for support of the Grants for Mathematics, Science, or Engineering Enrichment Courses.

Low-income Scholarship Program. Eligibility for the scholarships was expanded from the original fields of computer science, engineering, and mathematics to include "other technology and science programs designated by the Director." The maximum annual scholarship award amount was raised from $3,125 to $10,000. NSF may use up to 50 percent of funds "for undergraduate programs for curriculum development, professional and workforce development, and to advance technological education." Because of the changes, the program was renamed in 2006 from CSEMS to Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM).

Since its inception the low-income scholarship program has received approximately 2222 proposals from all types of colleges and universities and has made awards for 768 projects. Approximately 45,000 students have received scholarships ranging from one to four years, and many new grants have yet to award all their scholarships. In addition to scholarships, projects include student support activities featuring close involvement of faculty, student mentoring, academic support, and recognition of the students. Such activities are important in recruiting and retaining students in high-technology fields through graduation and into employment. Approximately 100 awards are anticipated in FY 2009.

ITEST Grants for Mathematics, Science, or Engineering Enrichment Courses. The ITEST program invests in K-12 activities that address the current concern about shortages of STEM professionals and information technology workers in the U.S. and seeks solutions to help ensure the breadth and depth of the STEM workforce, including education programs for students and teachers that emphasize IT-intensive careers. In FY 2008, the guidelines were revised to address the development, implementation, testing, and scale-up of models, as well as research studies to improve the STEM workforce and build students' capacity to participate in the STEM workforce, especially the information and communication technology (ICT) areas. The new ITEST solicitation extends the previous solicitation by placing greater emphasis on capturing and establishing a reliable knowledge base about the dispositions toward and knowledge about STEM workforce skills in U.S. students; the name of the program was also changed in this solicitation to Innovative Technology Experiences for Students and Teachers. New categories of awards include: (1) *Strategies projects* for the design, implementation, and evaluation of models for classroom, after-school, summer, virtual, and/or year-round learning experiences for students and/or teachers to encourage students' readiness for, and their interest and participation in the STEM workforce; (2) *Scale-Up projects* that support the implementation and testing of models that prepare students for information technology or the STEM workforce in a large-scale setting such as a state or at the national level; and (3) *Studies projects* that support research to enrich the understanding of issues related to enlarging the STEM workforce, including efficacy and effectiveness studies of intervention models, longitudinal studies, instruments, and studies to identify predictors of student inclination to pursue STEM career trajectories. The Strategies, Scale-up, and Studies projects replace the previous four components: youth-based projects, comprehensive projects, traditional project renewals, and the ITEST resource center.

Since its inception, ITEST has funded 115 local projects that allow students and teachers to work closely with scientists and engineers on extended research projects, ranging from biotechnology to environmental resource management to programming and problem-solving. Projects draw on a wide mix of local resources, including universities, industry, museums, science and technology centers, and school districts in order to identify the characteristics that engage a wide range of young people in STEM, especially those not successful in traditional school settings. Through a projected $110 million federal investment, ITEST impacts an estimated 130,000 students (grades 6-12), 4,300 teachers, and 1,600 parents/caregivers.

In FY 2007, ITEST received 124 full proposals and funded 30 awards, the highest number of awards in the five years of the program's existence.

In November 2005, Public Law 109-108 was signed and directed EHR to initiate a K-8 pilot program, which NSF called Academies for Young Scientists, using funds in the FY 2006 EHR appropriation. EHR used approximately $7 million of funds from its formal K-12 programming and approximately $7 million of funds from H-1B nonimmigrant petitioner fees for this effort. This effort called for proposals to develop stimulating, intensive STEM learning experiences that engage K-8 students; develop sustainable, district-based partnership demonstration projects; and promote strategies that further develop skills in K-8 STEM teachers. This activity was a demonstration project in FY 2006; no additional funds are requested. Sixteen projects are underway using a variety of promising strategies for engaging schools, business higher education, and informal science education organizations to motivate students in STEM and encourage their future involvement in the STEM workforce. A program resource center, established in 2007, has designed monitoring systems for looking at common data across sites, helped to launch a compressed longitudinal study to examine students' participation in STEM over time, and initiated a set of evaluation case studies on how various approaches can motivate and engage students in STEM.

H-1B Financial Activities from FY 1999 - FY 2007

(Dollars in Millions)

	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Receipts	**$26.61**	**$48.61**	**$88.34**	**$61.04**	**$65.34**	**$0.57**	**$83.68**	**$105.32**	**$107.36**
Obligations incurred									
Computer Science, Engineering, and Mathematics Scholarships	0.26	23.16	68.37	34.69	25.30	33.91	0.54	80.95	100.04
Grants for Mathematics, Engineering or Science Enrichment Courses	-	0.20	4.22	5.83	16.27	-	-	-	-
Systemic Reform Activities	-	1.70	3.70	3.97	5.00	2.50	2.72	-	-
Private-Public Partnership in K-12[1/]	-	-	2.22	12.82	-	20.87	22.69	18.45	45.90
Total Obligations	**$0.26**	**$25.06**	**$78.51**	**$57.31**	**$46.57**	**$57.28**	**$25.95**	**$99.40**	**$145.94**
Unobligated Balance end of year	$26.35	$49.89	$59.72	$63.45	$83.90	$29.10	$89.58	$98.19	$63.37

1/P.L 106-313 directs that 15 percent of the H-1B Petitioner funds go toward K-12 activities involving private-public partnerships in a range of areas such as materials development, student externships, math and science teacher professional development, etc.

Explanation of Carryover

With regard to the carryover into FY 2008, significant amounts of receipts arrived late in the fiscal year and there was not adequate time to obligate the total amounts. NSF is planning earlier deadlines for the S-STEM and ITEST programs in FY 2008 so that it can make awards from H-1B visa funds earlier in the fiscal year. A carryover from FY 2008 into FY 2009 is likely if, as has been the case in previous years, most receipts arrive late in the fiscal year.

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION $147,510,000

The FY 2009 Budget Request for the Major Research Equipment and Facilities Construction (MREFC) account is $147.51 million, a decrease of $73.23 million, or 33.2 percent, from the FY 2008 Estimate of $220.74 million.

Major Research Equipment and Facilities Construction Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change Over FY 2008 Estimate Amount	Percent
Major Research Equipment and Facilities Construction	$166.21	$220.74	$147.51	$73.23	-33.2%

The MREFC account supports the acquisition, construction, and commissioning of major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering. Initial planning and design, and follow on operations and maintenance costs of the facilities are provided through the Research and Related Activities (R&RA) account.

MREFC Account Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate
Ongoing Projects								
AdvLIGO	-	$32.75	$51.43	$46.30	$15.21	$23.73	$15.50	$19.78
ARRV	2.58	42.00	-					
ALMA[1]	64.30	102.07	82.25	42.76	13.91	3.00	-	-
EarthScope[2]	25.93	-	-					
IceCube	24.38	25.91	11.33	0.95	-			
NEON	-	3.00	-					
OOI	-	5.91	-					
SODV[2]	42.83	-	-					
SPSM	6.19	9.10	-					
New MREFC Funding								
ATST	-	-	2.50	-				
MREFC Account Total	$166.21	$220.74	$147.51	$90.01	$29.12	$26.73	$15.50	$19.78

Totals may not add due to rounding.

[1]The FY 2009 Request for ALMA is increased by $7.50 million relative to the re-baselined profile in order to allow more strategic use of project contingency to buy down near-term risk, as recommended by the 2007 annual external review. The increase in FY 2009 is offset by a matching decrease in FY 2011.

[2]EarthScope and SODV received the final year of MREFC funding in FY 2007. Information on these projects can be found in the Facilities chapter of this document.

A modern and effective research infrastructure is critical to maintaining U.S. leadership in science and engineering (S&E). The future success of entire fields of research depends upon access to new generations of powerful research tools. Increasingly, these tools are large and complex, and have a significant information technology component.

Among federal agencies, NSF is a primary supporter of forefront instrumentation and facilities for the academic research and education communities. In recent years, the number of funding requests for the construction of major research facilities and equipment from the S&E community has increased. Many of these requests have received reviews from research peers, program staff, management and policy officials, and the National Science Board (NSB); however, many projects have experienced schedule delays, increased costs, and/or decreased scope. NSF's FY 2009 request for the MREFC account adheres to tighter standards that projects must meet to receive funding from this account. These standards should minimize future cost overruns and schedule slips, allowing NSF to more effectively direct its funds to meet the future needs and opportunities of the research community.

In accordance with the plan outlined in *A Joint National Science Board-National Science Foundation Management report on Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation,* NSF developed guiding documentation for the MREFC process. NSF is releasing its *Facility Plan* in conjunction with this Budget Request, and the *Large Facilities Manual*, which supersedes and incorporates the former *Guidelines for Planning and Managing the Major Research Equipment and Facilities Construction (MREFC) Account* and the *Facilities Management and Oversight Guide*, was released in May 2007. These documents can be found on the NSF website[1].

In order for a project to be considered for MREFC funding, NSF requires that it represent an exceptional opportunity that enables research and education. In addition, the project should be transformative in nature in that it should have the potential to shift the paradigm in scientific understanding and/or infrastructure technology. The projects included in this Budget Submission meet these criteria based on NSF and NSB review.

MREFC projects under consideration for MREFC funding must undergo a multi-phase review and approval process that is described in detail in the *Large Facilities Manual*. As a general framework for priority setting, NSF assigns highest priority to ongoing projects, which are those that have received funding for implementation and where outyear funding for the full project has already been included in a Budget Request to Congress.

All of the projects in the MREFC account are undergoing or have undergone major cost and schedule reviews, as required by guidelines instituted by NSF over the last few years. NSF requests funding for three ongoing projects: Advanced LIGO (AdvLIGO), the Atacama Large Millimeter Array (ALMA) and the IceCube Neutrino Observatory (IceCube).

No additional MREFC funding is requested for the Alaska Region Research Vessel (ARRV), the National Ecological Observatory Network (NEON), or the Ocean Observatories Initiative (OOI) in FY 2009. To help avoid future cost and schedule overruns, MREFC funds will only be requested once a risk adjusted cost has been defined for each project that defines, with high confidence, the budgetary resources and schedule needed to accomplish the requested scope. These projects will be eligible for additional MREFC construction funding in a future budget request following successful completion of Preliminary and Final Design Reviews (FDRs). Until they have passed these approved performance baselines, these projects will continue to be supported by the sponsoring research directorates as they carry out the range of activities necessary to achieve sufficient project maturity.

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[1] *A Joint National Science Board-National Science Foundation Management report on Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*: www.nsf.gov/pubs/2005/nsb0577/nsb0577_1.pdf
NSF 2008 Facility Plan: www.nsf.gov/pubs/2008/nsf0824/nsf0824.pdf
Large Facilities Manual: www.nsf.gov/pubs/2007/nsf0738/nsf0738.pdf

In FY 2009, NSF is requesting funding for the Advanced Technology Solar Telescope (ATST). MREFC funding in the amount of $2.50 million is requested to support design activities. The use of these funds will require a determination by the NSF Director – in consultation with the NSB – that these funds are necessary to complete a construction-ready design. The use of MREFC funding for design and other pre-construction activities is a principal focus of ongoing reviews of NSF's MREFC processes by NSF management and the NSB.

NSF is implementing a "no cost overrun" policy, which will require that cost estimate developed at the Preliminary Design Stage have adequate contingency to cover all foreseeable risks, and that any cost increases not covered by contingency be accommodated by reductions in scope. NSF senior management is developing procedures to assure that the cost tracking and management processes are robust and that the project management oversight has sufficient authority to meet this objective. As project estimates for the current slate of projects are revised, NSF will identify potential mechanisms for offsetting any cost increases in accordance with this policy.

Appropriation Language

For necessary expenses for the acquisition, construction, commissioning, and upgrading of major research equipment, facilities, and other such capital assets pursuant to the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-1875), including authorized travel, ~~$220,740,000,~~*$147,510,000,* to remain available until expended: *Provided, That funds may be utilized for design, subject to the approval of the Director of the National Science Foundation in consultation with the National Science Board.*

Major Research Equipment and Facilities Construction
FY 2009 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Carryover/ Recoveries	Transfers	P.L. 110-161 Rescission	Total Resources	Obligations Incurred/Est.
FY 2007 Appropriation	$190.88	$2.93	-		$193.81	$166.21
FY 2008 Estimate	220.74	27.60	-	-15.27	233.07	233.07
FY 2009 Request	147.51	-	-		147.51	147.51
$ Change from FY 2008						-$85.56
% Change from FY 2008						-36.7%

Totals may not add due to rounding.

Explanation of Carryover:

Within the **Major Research Equipment and Facilities Construction (MREFC)** appropriation, a total of $27.60 million was carried forward into FY 2008, of which $15.27 million is rescinded as required under P.L. 110-161. The remaining $12.33 million of MREFC carryover will be applied to ongoing projects.

A total of $5.12 million was carried forward into FY 2008 for the *Ocean Observatories Initiative* (OOI). This amount is rescinded, as required under P.L. 110-161.

A total of $4.0 million was carried forward into FY 2008 for the *National Ecological Observatory Network* (NEON). This amount is rescinded, as required under P.L. 110-161.

A total of $51,934 was carried forward into FY 2008 for the *Scientific Ocean Drilling Vessel* (SODV). This amount is rescinded, as required under P.L. 110-161.

South Pole Station Modernization carried forward a total of $3.08 million into FY 2008 of which $2.55 million is rescinded, as required under P.L. 110-161. The remaining $531,375 will be applied toward the logistics and warehousing facility at South Pole, completion of exterior activities for the elevated station, and demolition of the existing station and other construction as the project approaches its scheduled completion in 2010.

A total of $4.27 million was carried forward into FY 2008 for the *IceCube Neutrino Observatory* (IceCube) of which $3.53 million was rescinded, as required under P.L. 110-161. The balance of $736,170 will be applied toward remaining construction items for IceCube as the project approaches its scheduled completion in 2010.

A total of $4.21 million was carried forward for remaining construction items for *EarthScope* as the project approaches its scheduled completion in 2008.

NSF obligated $2.58 million of the appropriated $9.43 million for the *Alaska Region Research Vessel* (ARRV) for updated engineering drawings and preparing the project execution plan, awarded during FY 2007. The remaining carryover of $6.85 million will be competed and awarded in FY 2008 and will include acquisition planning, shipyard contract award, design verification, and ordering of long lead equipment items.

Unallotted funds totaling $26,222 were rescinded, as required under P.L. 110-161.

ONGOING PROJECTS IN FY 2009:

NSF's ongoing projects in FY 2009 include:

- Advanced LIGO,
- the Alaska Region Research Vessel,
- the Atacama Large Millimeter Array,
- the IceCube Neutrino Observatory,
- the National Ecological Observatory Network,
- the Ocean Observatories Initiative, and
- The South Pole Station Modernization project.

Information on these projects follows.

Advanced Laser Interferometer Gravitational-Wave Observatory **$51,430,000**

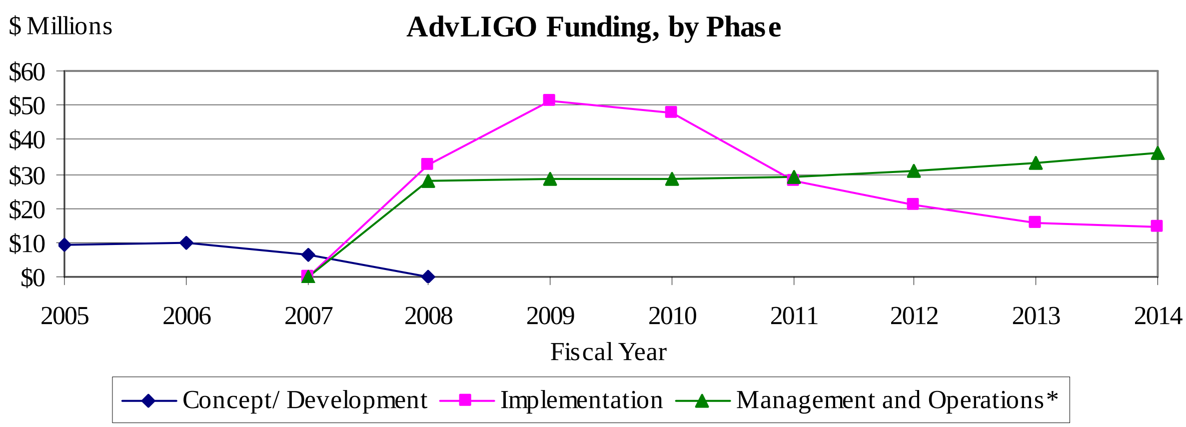
The FY 2009 Budget Request for the Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO) is $51.43 million, which represents the second year of a seven-year project totaling an estimated $205.12 million.

MREFC Funding for the Advanced Laser Interferometer Gravitational-wave Observatory
Appropriations and Requests
(Dollars in Millions)

FY 2008 Estimate	FY 2009 Request	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Total
$32.75	$51.43	$46.30	$15.21	$23.73	$15.50	$19.78	$0.42	$205.12

Baseline History: NSF first requested FY 2008 construction funds for AdvLIGO through the MREFC account in the FY 2006 Budget Request to Congress. The original proposal received in 2003 estimated a total construction cost of $184.35 million. The baseline review in June 2006 established the project cost at $205.12 million, based upon the known budget inflators at the time and a presumed start date of January 1, 2008. A second baseline review, held in June 2007, confirmed this cost, subject to changes in budget inflators. The Final Design Review in November 2007 recommended that construction begin in FY 2008.

AdvLIGO is the planned upgrade of the Laser Interferometer Gravitational-Wave Observatory (LIGO) that will allow LIGO to approach the ground-based limit of gravitational-wave detection. LIGO consists of the world's most sophisticated optical interferometers, operating at two sites (Hanford, WA and Livingston, LA) 3000 km apart. These interferometers are designed to measure the changes in arm-lengths resulting from the wave-like distortions of spacetime caused by the passage of gravitational waves. LIGO is sensitive to changes as small as one-one thousandth the diameter of a proton over the 4-km arm-length; AdvLIGO is expected to be at least 10 times more sensitive. The LIGO program has stimulated strong interest in gravitational-wave research around the world, producing vigorous programs in other countries that provide strong competition as well as highly beneficial collaborations. LIGO has pioneered the field of gravitational-wave detection, and a timely upgrade is necessary to reap the fruits of this bold initiative.

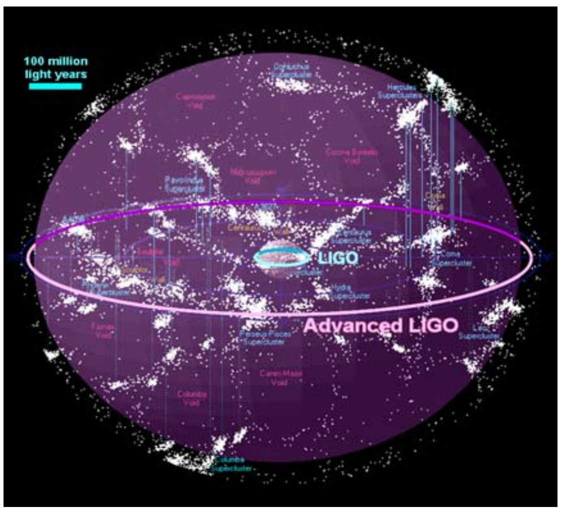


*Operations and Management refers to the continued operations of LIGO during the construction phase and the onset of operations for the newly constructed Advanced LIGO in FY 2015.

Total Obligations for AdvLIGO

(Dollars in Millions)

	Prior Years	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
R&RA Obligations:									
Concept & Development	34.50	6.24	-						
Management and Operations	-	33.00	29.50	28.50	28.50	29.00	31.00	33.00	36.00
Subtotal, R&RA Obligations	$34.50	$39.24	$29.50	$28.50	$28.50	$29.00	$31.00	$33.00	$36.00
MREFC Obligations:									
Construction	-	-	32.75	51.43	46.30	15.21	23.73	15.50	19.78
Subtotal, MREFC Obligations	-	-	$32.75	$51.43	$46.30	$15.21	$23.73	$15.50	$19.78
Total: AdvLIGO Obligations	$34.50	$39.24	$62.25	$79.93	$74.80	$44.21	$54.73	$48.50	$55.78



The MREFC Project Advanced LIGO will improve the sensitivity of LIGO by more than a factor of 10, which will expand the volume of space LIGO will be able to "see" by more than 1,000. Each small dot in the figure represents a galaxy. Credit: R. Powell, www.anzwers.org/free/universe/nearsc.html

LIGO has been a significant source of highly trained Ph.D. graduates for the country's workforce. Active outreach programs have been developed at both the Livingston and Hanford sites. Teams at both sites have provided visual displays, hands-on science exhibits, and fun activities for visiting students and members of the public. In the last three years an average of over 2,000 students per year have taken advantage of this opportunity. More formal programs at the sites include participation in the Research Experiences for Teachers (RET) Program, a set of "scientist-teacher-student" research projects in support of LIGO, and participation in the Summer Undergraduates Research Fellowships/Research Experiences for Undergraduates (SURF/REU) programs for college students. Both sites have developed Web-based resources for teachers that include information on research opportunities for schools and a set of standards-based classroom activities, lessons, and projects related to LIGO science. The LIGO Science Education Center at the Livingston, LA site was recently dedicated and has been filled with Exploratorium exhibits; it will be the focal point for augmenting teacher education at Southern University and other student-teacher activities state-wide through the Louisiana Systematic Initiative Program.

Substantial connections with industry have been required for the state-of-the-art construction and measurements involved in the LIGO projects. Some have led to new products. Areas of involvement include novel techniques for fabrication of LIGO's vacuum system, seismic isolation techniques, ultrastable laser development (new product introduced), high-power active optical components (new products introduced) development of new ultra-fine optics polishing techniques, and optical inspection equipment (new product).

LIGO has extensive international ties. The LIGO Scientific Collaboration, which sets the scientific agenda for LIGO, has formal ties with institutions from 11 foreign countries, and close collaboration is maintained with two other gravitational-wave observatories: GEO, a UK-German collaboration, and Virgo, a French-Italian collaboration. LIGO has recently signed an agreement with Virgo under which all data will be shared and analyzed cooperatively and all discoveries will be jointly credited. New technologies critical to AdvLIGO are being contributed by foreign institutions: the pre-stabilized laser source, funded and developed by the Max Planck Gesellschaft, and the mirror/test mass suspension systems, funded and developed by the GEO collaboration. The former has essentially attained its design specifications; the latter are being tested in European gravitational-wave facilities.

Project Report:

Management and Oversight:

- NSF Structure: NSF oversight is coordinated internally by a dedicated LIGO program director in the Division of Physics (MPS), who also participates in the LIGO Advisory Team (LIGO PAT). The LIGO PAT includes staff from the Offices of Budget Finance and Award Management (BFA), General Counsel (OGC), and Legislative and Public Affairs (OLPA). Formal reporting consists of a submitted annual report, submitted quarterly reports, and brief monthly update reports to the LIGO program officer, who in turn reviews, edits, comments and submits the final reports to the Deputy Director–Large Facility Projects. LIGO also submits periodic progress indicators within the provisions of the Government Performance and Results Act (GPRA) of 1993.

- External Structure: LIGO is managed by California Institute of Technology (Caltech) under a Cooperative Agreement. The project has a detailed management structure in place.

- Reviews:

  - Technical Reviews: NSF conducts annual scientific and technical reviews involving external reviewers and participates in meetings of the LIGO Scientific Collaboration (LSC) as well as making site visits to the Hanford, WA and Livingston, LA interferometers.
  - Management, Cost, and Schedule Reviews: (1) AdvLIGO construction proposal review in 2003; (2) First baseline review in June, 2006; (2) Second baseline review in June, 2007. (3) Final readiness review in November, 2007.
  - Upcoming Reviews: A technical and management, cost, and schedule review is planned for June, 2008.

Current Project Status:

A request for MREFC funding for AdvLIGO construction to begin April 1, 2008, is being submitted to the National Science Board for final approval at the March 2008 meeting.

Cost and Schedule:

The projected length of the project is 7 years, with an 11-month schedule contingency. The risk-adjusted cost of $205.12 million includes a contingency budget of 23.7 percent.

Alaska Region Research Vessel $0.0

No additional funds are requested for the Alaska Region Research Vessel (ARRV) through the MREFC account in FY 2009.

MREFC Funding for the Alaska Region Research Vessel

Appropriations and Requests

(Dollars in Millions)

FY 2007 Appropriation	FY 2008 Estimate	FY 2009 Request
$9.43	$42.00	-

Baseline History: NSF first requested construction funding for ARRV through the MREFC account in FY 2007, and received an initial appropriation of $9.43 million in that year. In FY 2009, NSF is delaying acquisition of the ARRV to incorporate updated pricing information into the construction plan. Rapid inflation in the shipbuilding industry has made it difficult to accurately project the final construction cost for the ARRV, but revised funding estimates are planned prior to a Final Design Review (FDR), expected to be held later in 2008. The current notional baseline for the ARRV project will be refined in accordance with an ongoing update of the technical scope of the ship design to meet current regulatory body requirements, the recently updated science mission requirements, the update of the University of Alaska Fairbanks-proposed construction schedule, and the independent cost estimates for construction. The formal baseline will be established once the ARRV construction contract is awarded to a shipbuilding firm. If the FDR later this year is successful, the project will be eligible to request additional MREFC funding for construction.

The ARRV will replace the R/V *Alpha Helix*, which, at 40 years of age prior to its decommissioning, was the oldest ship in the national academic research fleet. Science activities in this region have been limited by the capabilities of the Alpha Helix, which was restrictively small and could not operate in ice or in severe winter weather in the open seas. With its ice-strengthened hull, the ARRV will be built to operate year round in the challenging waters of the Chukchi, Beaufort, and Bering Seas, as well as the open Gulf of Alaska, coastal Southeast Alaska, and Prince William Sound, including operations in seasonal ice up to 2.5 feet in thickness.

Total Obligations for the ARRV

(Dollars in Millions)

	Prior Years	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
R&RA Obligations:									
Concept & Development	2.24	-							
Management and Operations	-								
Subtotal, R&RA Obligations	$2.24	-	-	-	-	-	-	-	-
MREFC Obligations:									
Implementation	-	2.58	48.85	-					
Subtotal, MREFC Obligations	-	$2.58	$48.85	-	-	-	-	-	-
Total ARRV Obligations	**$2.24**	**$2.58**	**$48.85**	**-**	**-**	**-**	**-**	**-**	**-**

Satellite observations have shown that the perennial ice in the Arctic is thinning at a rate of 9 percent per decade, which is beginning to have major regional and global consequences. Research is urgently needed on topics ranging from climate change, ocean circulation, ecosystem studies, and fisheries research to natural hazards and cultural anthropology. Further, the ARRV will provide a sophisticated and significantly larger platform for scientists and graduate and undergraduate students to participate in complex multidisciplinary research activities and will enable the training of the next generation of scientists with the latest equipment and technology. Broadband satellite connections capable of relaying data, including high definition video from tools such as remotely operated vehicles that explore under the ice and the ocean depths, will bring research into the K-12 classroom and to the general public.

The construction phase of the project is being lead by UAF. To date, extensive design work has been undertaken by Glosten and Associates.

It is anticipated that the ARRV will greatly expand research capabilities in the region, going from a maximum of 160 ship operating days with the R/V *Alpha Helix*, up to 275-300 days with the ARRV. The vastly increased capability of the ARRV, both with regard to its ability to accommodate much larger interdisciplinary research teams and greatly enlarged geographical and seasonal ranges, will dramatically increase the number of proposals addressed to NSF for its utilization. Individual projects vary greatly in cost, as do the number of projects supported onboard at any given time. Assuming two simultaneous projects onboard for 3-4 weeks at a time and average grant size in the Division of Ocean Sciences, over $7.0 million in research would be supported annually.

This image is an artist's rendition of the ARRV, proposed to replace the R/V *Alpha Helix*, which, at 39 years is the oldest ship in the national academic research fleet.

A phased approach for ARRV project execution has been established within the cooperative agreement with UAF, in which successful achievement and review of sequential milestones for each phase are essential for proceeding to successive phases. Phase I, which is primarily updating engineering drawings and preparing the project execution plan, was awarded during FY 2007 and funded in the amount of $2.58 million. Phase 2, which includes acquisition planning, verification of shipyard qualification, and design verification, will be awarded in FY 2008 and completed in FY 2009. Phase 3, shipyard construction, testing and sea trials of the vessel, is contingent on successful completion of Phase 2 and future appropriation of construction funds. Phase 4 of the project, the final construction phase, includes Science Outfitting and Ice Operational Testing.

Project Report

Management and Oversight:

- NSF Structure: The NSF coordinator is the Program Director for Ship Acquisition and Upgrades, within the Integrative Programs Section (IPS) in the Division of Ocean Sciences, Directorate for Geosciences (GEO). Additional staff in IPS provides project management assistance. Internal oversight for the construction cooperative agreement is provided by a Project Advisory Team (PAT) which includes staff from GEO, the Office of Budget, Finance, and Award Management (BFA), including the BFA Deputy Director for Large Facility Projects, and the Office of the General Counsel (OGC). The baseline will be established following award of the shipyard contract but prior to any construction funds being released. In addition, the University-National Laboratory System (UNOLS)

Fleet Improvement Committee, an external committee composed of representatives from the community that meets several times a year, will review progress and provide advice regarding scientific outfitting of the vessel.

- External Structure: UAF has established a project management office in Fairbanks, AK, a component of which includes an on-site team that will remain in the shipyard throughout the construction process. The ARRV Oversight Committee, which includes community experts in research vessel design, construction, and operations, has been commissioned and convenes monthly to review project status and provide technical and project management advice to UAF and NSF personnel.

- Reviews:

  - Technical reviews: The Design Verification Review, during which time the shipyard will review and refine the contract design to build the ARRV to suit their production facilities within the contract price, will be completed during early FY 2009.
  - Management, Cost, and Schedule reviews: The Oversight Committee will continue to hold monthly teleconferences of project status and quarterly reviews of ARRV project management, cost, and schedule.
  - Upcoming reviews: A formal ARRV Final Design Review will be held during late FY 2008, and, contingent on appropriation of operating funds and following shipyard selection, a Baseline Review will be held to clearly articulate the project's cost, schedule, and scope, against which progress will be measured.

<u>Current Project Status:</u>

Phase 1 tasks, which will be completed in early FY 2008, include update of the ship design technical package and cost estimate, finalization of the UAF project management team and oversight committee, development of the Project Execution Plan, establishment of an earned value management reporting system for the project, and market surveillance of interested and qualified shipyards. Phase 2 will be awarded in FY 2008 and includes verification of shipyard interest and design verification, and will be completed during FY 2009. Phase 2 work will include a Final Design Review to ensure that all University of Alaska plans for construction and risk mitigation are sound and in place prior to the solicitation of bids from shipyards.

<u>Cost and Schedule:</u>

Phase 1 of the ARRV project will be completed within cost and in accordance with the schedule set forth in the cooperative agreement with the University of Alaska. Phase 2 is similarly expected to fall within the cost and schedule requirements of the cooperative agreement upon completion in FY 2009. The Final Design Review will firmly establish the Earned Value parameters reflecting project cost, schedule, and overall progress.

<u>Risks:</u>

A formal risk assessment and management plan will be developed in accordance with NSF guidelines. The Risk Management Plan and Risk Register will be continually updated and formally reviewed prior to the execution of each Phase of the project. Significant risks at this stage of the project include: schedule slip, which would result in project cost increases due to inflation; shipyard market risk; shipyard contract disputes and claim potential; risks associated with design development due to changing regulatory body requirements and; owner initiated design changes.

Future Operations Costs:

Initial science operations, to be governed by the terms of a separate cooperative agreement with UAF, have an estimated vessel operating cost of $8.50 million, with funding provided by NSF and other agencies according to use level. This estimate is based on NSF's extensive experience operating research vessels in a variety of environments.

Atacama Large Millimeter Array $82,250,000

The FY 2009 Budget Request for the Atacama Large Millimeter Array (ALMA) is $82.25 million, which represents the eighth year of an eleven year project totaling an estimated $499.26 million.

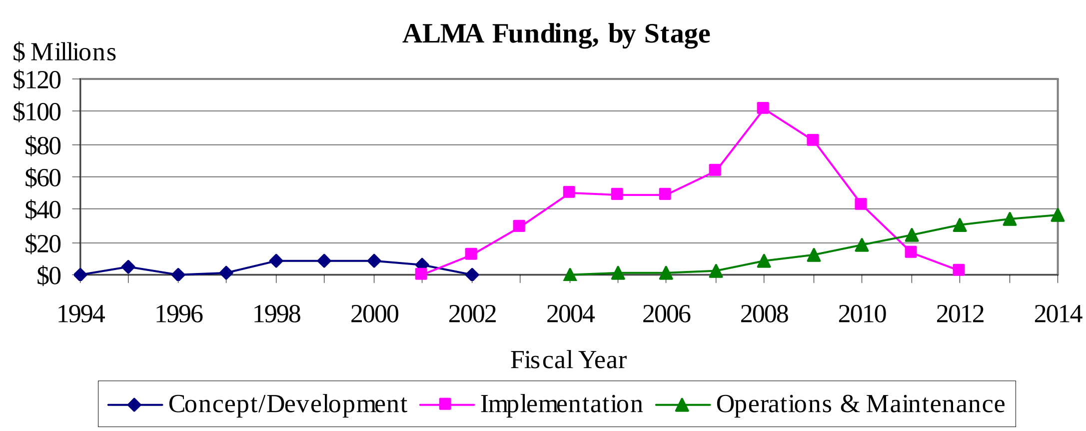
Appropriated and Requested MREFC Funds for the Atacama Large Millimeter Array
(Dollars in Millions)

FY 2005[1] &Earlier	FY 2006	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	Total
$142.31	$48.66	$64.30	$102.07	$82.25	$42.76	$13.91	$3.00	$499.26

[1]An additional $31.99 million was appropriated through the MREFC account prior to FY 2005 for concept and development.

Baseline History: NSF first requested design and development funds through the MREFC account for ALMA, then called the Millimeter Array, in FY 1998. Construction funding for ALMA was first appropriated in FY 2002, and the U.S. cost of the project was established at $344.13 million. The ALMA Board initiated rebaselining in the fall of 2004 under the direction and oversight of the Joint ALMA Office (JAO) Project Manager. The project was at that point sufficiently mature that the baseline budget and schedule established in 2002, prior to the formation of the partnership, could be refined based on experience. The rebaselining process took approximately one year, scrutinizing cost and schedule throughout the project, assessing technical and managerial risk, and ultimately revising the assumptions on the scope of the project. The new baseline plan developed by the JAO assumed a 50-antenna array as opposed to the original number of 64, extended the project schedule by 24 months, and established a new U.S. total project cost of $499.26 million. The FY 2009 Request is increased by $7.50 million relative to the re-baselined profile in order to allow more strategic use of project contingency to buy down near-term risk, as recommended by the 2007 annual external review. The increase in FY 2009 is offset by a matching decrease in FY 2011.

The global ALMA project will be an aperture-synthesis radio telescope operating in the wavelength range from 3 to 0.4 mm. ALMA will be the world's most sensitive, highest resolution, millimeter-wavelength telescope, combining sub-arcsecond angular resolution with the sensitivity of a single antenna nearly 100 meters in diameter. The array will provide a testing ground for theories of planet formation, star birth and stellar evolution, galaxy formation and evolution, and the evolution of the universe itself. The interferometer is under construction at 5,000 meter altitude near San Pedro de Atacama in the Second Region of Chile, the ALMA host country.



Total Obligations for ALMA
(Dollars in Millions)

	Prior Years	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
R&RA Obligations:									
Concept & Development	6.50	-							
Management and Operations	2.50	3.71	8.22	11.77	17.57	23.50	30.65	33.92	36.41
Subtotal, R&RA Obligations	$9.00	$3.71	$8.22	$11.77	$17.57	$23.50	$30.65	$33.92	$36.41
MREFC Obligations:									
Concept & Development	31.99	-							
Implementation	190.97	64.30	102.07	82.25	42.76	13.91	3.00	-	
Subtotal, MREFC Obligations	$222.96	$64.30	$102.07	$82.25	$42.76	$13.91	$3.00	-	-
Total: ALMA Obligations	**$231.96**	**$68.01**	**$110.29**	**$94.02**	**$60.33**	**$37.41**	**$33.65**	**$33.92**	**$36.41**

Once completed, ALMA will function as the most capable imaging radio telescope ever built and will bring to millimeter and submillimeter astronomy the high-resolution aperture synthesis techniques of radio astronomy. ALMA will image at 1 millimeter wavelength with the same 0.1 arcsecond resolution achieved by the Hubble Space Telescope at visible wavelengths, and will form a critical complement to the leading-edge optical, infrared, ultraviolet, and x-ray astronomical instruments of the twenty-first century.

ALMA will play a central role in the education and training of U.S. astronomy and engineering students; at least 15 percent of ALMA's approximately 1,000 yearly users are expected to be students. There is already substantial involvement by graduate students in applied physics and engineering at universities participating in the ALMA Design and Development program, providing an opportunity to broaden participation in science and engineering by members of under-represented groups.

Extensive public and student ALMA outreach programs will be implemented in North America, Europe, and Chile as ALMA approaches operational status. A visitors' center will be constructed at the 2,800 meter-altitude Operations Support Facility gateway to the ALMA site near San Pedro de Atacama in northern Chile. The project also supports a fund for the Antofagasta (II) Region of Chile that is used for economic, scientific, technical, social, and cultural development, particularly within the nearby towns of San Pedro de Atacama and Toconao.

The first Vertex antenna under assembly at the ALMA site in Chile. *Credit NRAO/AUI*

North America and Europe are equal partners in the core ALMA instrument. Japan joined ALMA as a third major partner in 2004, and will deliver a number of enhancements to the baseline instrument. The North American side of the project, consisting of the U.S. and Canada, is led by Associated Universities Incorporated/National Radio Astronomy Observatory (AUI/NRAO). Funding and execution of the project in Europe is carried out through the European Southern Observatory (ESO). Funding of the project in Japan is carried out through the National Institutes of Natural Sciences of Japan and project execution is the responsibility of the National Astronomical Observatory of Japan.

From an industrial perspective, ALMA instrumentation will push gallium arsenide and indium phosphide transistor amplifier technology to high frequencies, will challenge production of high-density, high-speed integrated circuits for computational uses, and is expected to stimulate commercial device and communication technologies development.

Peer-review telescope allocation committees will provide merit-based telescope time but no financial support. NSF will not provide awards targeted specifically for use of ALMA. Most U.S. users will be supported through NSF or NASA grants to pursue research programs that require use of ALMA.

Construction progress continues in FY 2008, both at the site in Chile and within the ALMA partner countries. The most significant events for the project in FY 2007 were delivery of the first antenna to Chile and astronomical interferometry between two prototype antennas in Socorro, New Mexico demonstrating the end-to-end electronics system. Early science operations are expected to commence in FY 2010 and completion of the construction project and the start of full science operations are planned to occur around the end of FY 2012.

Project Report:

<u>Management and Oversight:</u>

- NSF Structure: Programmatic management is the responsibility of the ALMA Staff Associate in the Division of Astronomical Sciences (AST) in the Directorate for Mathematical and Physical Sciences (MPS). An NSF advisory group consisting of representatives from the Office of General Counsel, the Office of Budget, Finance, and Award Management, the Office of International Science and Engineering, and the Office of Legislative and Public Affairs, serves as a standing ALMA Project Advisory Team. The NSF Deputy Director for Large Facility Projects (DDLFP) is a member of the PAT and provides advice and assistance.

- External Structure: AST's external Millimeter Array Oversight Committee has been advising NSF on the project since early 1998, and comprises half of the International ALMA Management Advisory Committee. Management of the NRAO effort on ALMA is carried out under a cooperative agreement with AUI. Oversight of the full international project is vested in the ALMA Board, whose membership includes an NSF member; coordination and management of the merged international efforts is the responsibility of the Joint ALMA Office (JAO), whose staff includes the ALMA Director, Project Manager, and Project Engineer.

- Reviews:

  - Technical reviews: The JAO holds frequent technical reviews at appropriate design and fabrication milestones. For example, a review of the readiness to begin receiver production was held in November 2007. A primary function of the AMAC is to audit the internal reviews on behalf of the ALMA Board.
  - Management, Cost, and Schedule reviews: NSF, through the ALMA Board, holds external reviews of the broad Project and in targeted areas. A review of the Operations Plan was conducted in February 2007. A project-wide annual review, held in September 2007, assessed management, cost and schedule performance, status, issues, and risks. NSF also directly charges external assessments, both broad-based e.g. through its review of the performance of the managing organization (AUI), and of specific areas as warranted. For example, a review of the computing group management and performance was held in May 2007.

- Upcoming reviews: Receiver production review in March 2008. Annual External Review in October 2008.

Current Project Status:

- Major project milestones attained in FY 2007 included:
  - Completion and provisional acceptance of AOS technical building
  - Delivery of first North American antenna to Chile
  - Integration of the first cryostat with receivers for each of the four initial wavebands in the North American integration center
  - Completion of operations reviews
  - Placement of European front end integration center contract

- Major milestones for FY 2008 are expected to include:
  - Delivery of the second through fifth North American production antennas to Chile
  - Delivery of the two antenna transporters
  - Delivery of the first two North American receiver front ends to Chile
  - Installation of the first quadrant of the correlator at the high-altitude site
  - Test interferometry at the mid-level facility in Chile using two antennas (very end of FY 2008)

- Major milestones for FY 2009 are expected to include:
  - Delivery of the first three European antennas to Chile
  - Installation of the second quadrant of the correlator
  - Delivery of the first four European and third through fifth North American front ends
  - Transport of several antennas to the final, high-altitude site in Chile
  - Start of commissioning

Cost and Schedule:

The current schedule performance is slightly behind plan due to equipment delivery delays, in particular delivery of the first antennas and receivers. The major milestones of early-science and full-science are under a tight schedule but remain achievable. Cost performance is very good at this stage in the project – cost variance is +1% and schedule variance is -5% relative to the 2005 baseline -- with approximately 40 percent contingency remaining in the uncommitted budget.

Risks:

- The transition from prototype and pre-production devices into production lines will occur across many areas of the project in the coming 18 months and is one of the key challenges for the project.
- The supply of 5MW of electricity to operate the full array has not been finalized due to the unstable power economy in Chile and South America. The original plan for gas-fed generators was eliminated following the cessation of gas exports from Bolivia. Consequently, project management is pursuing alternative options of electricity supply via a 160km-long overhead line to the nearest grid access point or on-site diesel power generation.
- For operations, the principal challenge is to ramp-up the staffing to 200 technically qualified personnel over the next three years.

Future Operations Costs:

Operations and maintenance funds phase in as initial site construction is completed and antennas begin to be delivered. Funds will be used to manage and support site and instrument maintenance, array operations in Chile, early science (FY 2011) and eventually full science operations, and in support of ALMA observations by the U.S. science community. Full ALMA science operations are anticipated to begin around the end of FY 2012. An Operations Plan and a proposal for North American operations were externally reviewed in FY 2007 and a funding profile through FY 2011 was authorized by the National Science Board in December 2007. The operations estimates for FY 2012 and beyond are based on current cost projections. The anticipated operational lifespan of this project is at least 30 years.

IceCube Neutrino Observatory $11,330,000

The FY 2009 Budget Request for the IceCube Neutrino Observatory is $11.33 million, which represents the eighth year of a nine-year project totaling an estimated $276.63 million. $242.07 million is funded through NSF's MREFC account, and the balance ($34.56 million) is provided by foreign partners in the project.

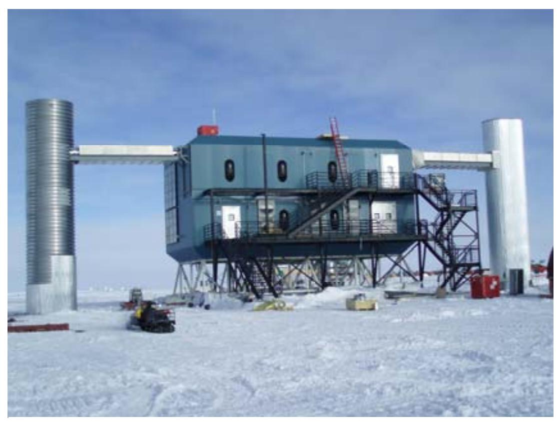
MREFC Funds for the IceCube Neutrino Observatory
Appropriations and Requests
(Dollars in Millions)

FY 2004 & Earlier	FY 2005	FY 2006	FY 2007	FY 2008 Estimate	FY 2009 Request	FY 2010 Estimate	Total
$81.29	$47.62	$49.85	$28.65	$22.38	$11.33	$0.95	$242.07

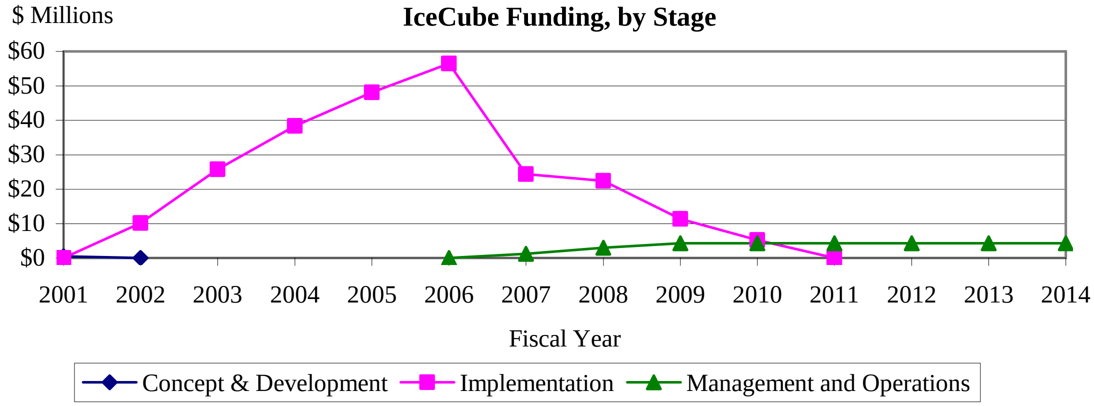
Baseline History: Congress provided an initial appropriation for IceCube of $15.0 million in FY 2002 and $24.54 in FY 2003 for "Start-up Activities", including development of an Enhanced Hot Water Drill. NSF requested construction funding for IceCube in the FY 2004 Budget Request, and the total cost of the project (including start-up activities) was estimated to be $271.77 million at that time ($242.07 from NSF and the balance from the international partners). NSF carried out a comprehensive external baseline review of the entire project, including cost, schedule, technical and management review, in February 2004; this rebaselining effort confirmed the U.S. total project cost of $242.07 million.

The total project cost is now $276.63 million, $4.86 million more than the initial estimate. This change is due to an increase in the value of the contributions made by foreign partners, which is now at $34.56 million. NSF's cost, however, remains constant at $242.07 million.

IceCube will be the world's first high-energy neutrino observatory and will be located deep within the ice cap under the South Pole in Antarctica. It represents a new window on the universe, providing unique data on the engines that power active galactic nuclei, the origin of high energy cosmic rays, the nature of gamma ray bursters, the activities surrounding supermassive black holes, and other violent and energetic astrophysical processes. Approximately one cubic kilometer of ice is being instrumented with photomultiplier (PM) tubes to detect neutrino-induced, charged reaction products produced when a high energy neutrino interacts in the ice within or near the cubic kilometer fiducial volume. An array of Digital Optical Modules (DOMs), each containing a PM and associated electronics, will be distributed uniformly from 1.5 km to 2.5 km beneath the surface of the South Pole ice cap, a depth where the ice is highly transparent and bubble-free. When completed, IceCube will record the energy and arrival direction of high-energy neutrinos ranging in energy from 100 GeV (10^{11} electron Volts [eV]) to 10 PeV (10^{16} eV).



IceCube Laboratory at the South Pole Station. The large towers contain signal cables from strings of Digital Optical Modules frozen into the ice extending down 2450m below the surface (above). Courtesy of the University of Wisconsin and the IceCube Project.



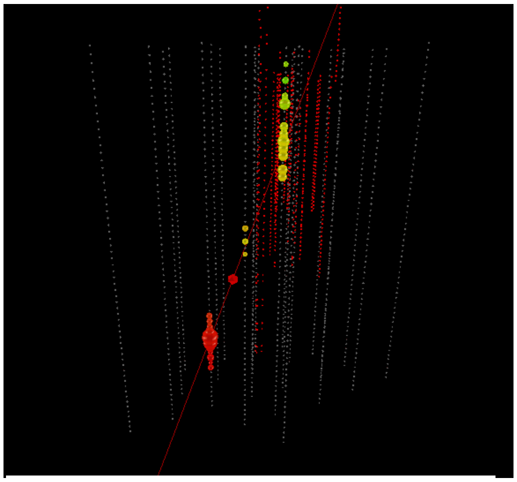
Total Obligations for IceCube
(Dollars in Millions)

	Prior Years	FY 2007 Actuals	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
R&RA Obligations:									
Concept & Development	0.50	-	-	-	-	-	-	-	-
Management and Operations	-	1.25	3.00	4.30	4.30	4.30	4.40	4.50	4.60
Subtotal, R&RA Obligations	$0.50	$1.25	$3.00	$4.30	$4.30	$4.30	$4.40	$4.50	$4.60
MREFC Obligations:									
Implementation	178.77	24.39	22.38	11.33	5.20	-	-	-	-
Subtotal, MREFC Obligations	$178.77	$24.39	$22.38	$11.33	$5.20	-	-	-	-
Total	**$179.27**	**$25.64**	**$25.38**	**$15.63**	**$9.50**	**$4.30**	**$4.40**	**$4.50**	**$4.60**

The principal tasks in the IceCube project are: production of the needed DOMs and associated electronics and cables; production of an enhanced hot water drill and a DOM deployment system capable of drilling holes for and deploying DOM strings in the ice at the Pole; refurbishment and outfitting of the IceCube Laboratory (ICL) at the South Pole; the actual drilling of the deep-ice holes, deployment of the needed DOMs, and their commissioning and verification; installation of a surface array of air shower detectors (‘IceTop’) to both calibrate and eliminate background events from the IceCube DOM array; construction of data acquisition, handling, archiving, and analysis systems; and associated personnel and logistics support.

IceCube construction is being carried out by the IceCube Collaboration, led by the University of Wisconsin (UW). The IceCube Collaboration consists of 12 U.S. institutions and institutions in three other countries: Belgium, Germany, and Sweden. NSF’s foreign partners are contributing approximately $34.56 million to the project, as well as a pro rata share of IceCube Maintenance and Operations costs based on the number of PhD-level researchers involved. The Department of Energy, through its Lawrence Berkeley National Laboratory, is also participating.

NSF will support activities at U.S. institutions working on more refined and specific data analyses, data interpretation (theory support), and instrumentation upgrades through ongoing research programs. The annual support for such activities will be provided through the R&RA account and is currently estimated at approximately $4.00 million once the facility reaches full operation.



Upward-moving neutrino (ν) event candidate recorded in the current array of 22 strings taken during 2007 (below). *Courtesy of the University of Delaware and the IceCube Collaboration.*

IceCube provides a vehicle for helping to achieve national and NSF education and outreach goals. Specific outcomes include the education and training of next-generation leaders in astrophysics, including undergraduate students, graduate students, and postdoctoral research associates; K-12 teacher scientific/professional development, including development of new inquiry-based learning materials and using the South Pole environment to convey the excitement of astrophysics, and science generally, to K-12 students; increased diversity in science through partnerships with minority institutions; and enhanced public understanding of science through broadcast media and museum exhibits based on IceCube science and the South Pole environment (one is currently under construction). Some of these outcomes will result from separate R&RA grants to universities and other organizations for work associated with IceCube, selected following standard NSF merit review. Funding for education and outreach activities, estimated at $400,000 annually, will be provided through the R&RA account.

Project Report:

Management and Oversight:

- NSF Structure: Oversight responsibility for IceCube construction is the responsibility of OPP, and a Project Coordinator manages and oversees the NSF award. Support for operations, research, education, and outreach will be shared by OPP and MPS as well as other organizations and international partners. Besides annual progress reviews and other specialized reviews (e.g., a safety review), the project provides monthly progress reports and quarterly reports. NSF conducts site visits, weekly teleconferences with the project managers, and internal NSF project oversight and management meetings.

- External Structure: The UW management structure for the IceCube project includes leadership by a Project Director and a Project Manager. At lower levels, project management includes international participation as well as participation by staff at collaborating U.S. institutions. This framework was put in place during the start-up phase of IceCube and provided a sound basis for initiation of full construction with FY 2004 funding as soon as the project was baselined. UW has in place an external Scientific Advisory Committee, an external Project Advisory Panel, and a high-level Board of Directors (including the UW Chancellor) providing awardee-level oversight of the project.

- Reviews: NSF carried out a comprehensive external baseline review of the entire project (including cost, schedule, technical, and management) in February 2004. There was a follow-up external cost review in Fall 2004. Comprehensive external reviews are held each spring following the annual deployment season; such reviews were held in May of 2005, 2006, and 2007. The next review is scheduled for May 2008.

Current Project Status:

- During FY 2007, the ICL, which will house the data acquisition and data handling systems, was granted conditional occupancy and all systems were successfully transitioned from their temporary location. The initial plan to drill, deploy, test, and commission 12-14 additional DOM strings and corresponding electronics and DAQ elements, for a total of 21-23 strings (30 percent of the planned array), was met with the completion of 13 strings and 20 new IceTop modules (two such modules are located over each string). Production and testing of the DOMs, IceTop modules, cables, and associated electronics needed for the 2007/2008 drilling and deployment season is complete. As of 24 January 2008, the high end of this season's goal of deploying 14-18 new DOM strings was met with the deployment of the 18th string. A significant milestone was reached when the IceCube Neutrino Observatory began limited operations for science at the beginning of May 2007, using 22 IceCube DOM strings, and the data acquisition system has performed well since then.

Cost and Schedule:

- IceCube is 79.7% complete in terms of earned value, well within the originally-proposed budget and approximately 2 quarters behind the originally-proposed completion schedule. The contingency on the budgeted cost of the work remaining is 23.6%, adequate to deal with remaining risk.

- Projected out-year milestones (FY 2008-2011) are based on current project planning and represent a general outline of anticipated activities. These activities are also dependent on weather conditions and the Antarctic logistics schedule.

- FY 2008-11 Milestones:
  - Completion, commissioning, and final acceptance of the ICL;
  - Continue DOM and IceTop module production and testing, and continue to drill, deploy, test, and commission strings (14 or more strings per season) and the corresponding IceTop modules, including installation and testing of the associated DAQ elements; and,
  - Ramp up to full operation of IceCube in FY 2011.

Risks:

- The Enhanced Hot Water Drill used to melt the 2.5 km water columns, into which the strings of DOMs are deployed, continues to perform well, with fuel efficiency better than planned and with a penetration rate that meets specifications. Of the DOMs deployed thus far, 98.5 percent are now working at or better than design specifications. Based on performance thus far, a mean-time-to-failure analysis predicts a survival fraction of 97 percent after 15 years, better than the original 95 percent reliability specification for the project. Installation of the IceTop surface array is proceeding according to schedule, with elements deployed on the surface at each string location. DOM production and cold-testing facilities in the U.S. and Europe continue to work with high efficiency, producing reliable DOMs that continue to meet or exceed requirements.

- Based on the above achievements, the project has retired major technical risks. A key factor to the success of IceCube, and a remaining risk, is the logistics support chain required to transport all material and personnel to the South Pole, and this, too, continues to perform at a very high level.

Future Operations Costs:

- Operations in support of scientific research began in FY 2007, and will ramp up in subsequent years to full science operations in FY 2011 following completion of drilling and DOM deployment in that year. The associated costs are and will continue to be shared by the partner funding agencies – U.S. (NSF) and non-U.S. – on a pro rata basis according to the number of PhD researchers involved (currently about 55:45). In the steady state, the annual cost of the data analysis that will be carried out by the collaborating U.S. and foreign institutions is estimated at $8.0 million, of which $4.00 million will come from NSF for the U.S. groups, and which is outside of support for operations (e.g., the data acquisition and data handling systems, data quality monitoring, information technology (IT) upgrades).

- The general operations of South Pole Station, reported in a separate section, also contribute to supporting IceCube. The cost of IceCube operations shown in the table herein includes only those that are project-specific and incremental to general South Pole Station operations. Progress in IceCube operations will be reviewed annually, as it is for the MREFC construction project. The expected operational lifespan of this project is 25 years beginning FY 2011.

The National Ecological Observatory Network $0.0

The FY 2009 Budget Request does not request construction funds for the National Ecological Observatory Network (NEON).

MREFC Funding for the National Ecological Observatory Network
Appropriations and Requests
(Dollars in Millions)

	FY 2007 Appropriation	FY 2008 Estimate	FY 2009 Request
NEON Appropriations and Request	$4.00	$3.00	-
Rescission	-$4.00		
Total, NEON	-	$3.00	-

$4.0 million of the FY 2007 appropriated funds for NEON were rescinded per PL 110-161

Baseline History: NSF first requested funds for NEON in FY 2001. In 2004 an NRC report evaluated the original NEON proposal and made recommendations that significantly altered the design to make it better suited for regional to continental scale ecological research. Congress appropriated MREFC funding for NEON in FY 2007 and FY 2008. A formal baseline for NEON will be reviewed in FY 2009 as part of a Final Design Review (FDR). Assuming successful completion of the FDR, the project will be eligible for additional MREFC construction funding in a future budget request.

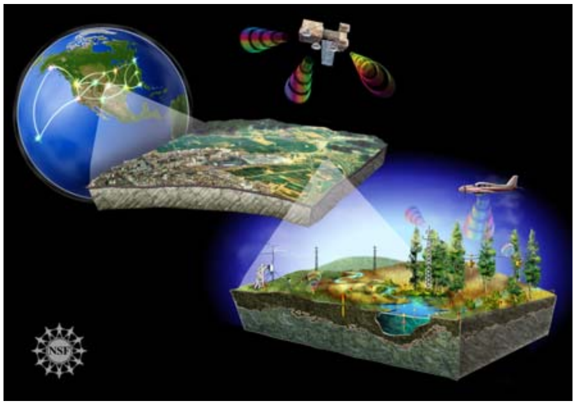
If constructed, the proposed NEON would consist of geographically distributed field and lab infrastructure networked via cybertechnology into an integrated research platform for regional to continental scale ecological research. Cutting-edge sensor networks, instrumentation, experimental infrastructure, natural history archive facilities, and remote sensing would be linked via the internet to computational, analytical, and modeling capabilities to create NEON's integrated infrastructure.

Total Obligations for NEON
(Dollars in Millions)

	Prior Years	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
R&RA Obligations:									
Concept & Development[1]	17.75	11.94	20.00	26.04	28.00	32.00	30.70	28.70	28.70
Management and Operations	-	-	-	-	-	-	-	-	-
Subtotal, R&RA Obligations	$17.75	$11.94	$20.00	$26.04	$28.00	$32.00	$30.70	$28.70	$28.70
MREFC Obligations:									
Construction	-	-	$3.00	-	-	-	-	-	-
Subtotal, MREFC Obligations	-	-	$3.00	-	-	-	-	-	-
Total: NEON Obligations	**$17.75**	**$11.94**	**$23.00**	**$26.04**	**$28.00**	**$32.00**	**$30.70**	**$28.70**	**$28.70**

[1] Included are costs for final Concept and Development and NEON, Inc. Consortium activities. In addition, costs for the NEON Project Office are included until construction begins.

Since NSF supports 63 percent of the fundamental environmental biology research at U.S. academic institutions, advances in the field of ecology, and the infrastructure to enable those advances, depend largely on support from NSF. Current research infrastructure is inadequate to enable studies to address the complex phenomena driving ecological change in real time and at the scales appropriate for studying many grand challenge questions in ecology. As a continent-wide research instrument, NEON will support a large and diverse group of organizations and individuals; foremost are the scientists, educators, and engineers who will use NEON infrastructure in their research and educational programs. NSF will support research performed using the NEON platform through a special competition and through ongoing research and education programs. Based on prior experience with other new activities, BIO expects that within 3-5 years proposal submission to regular programs to use NEON will have grown sufficiently to negate the need for a special competition, and resources dedicated to the competition will be transferred to core programs. A NEON cyberinfrastructure gateway will provide resources to support formal and informal public education and provide opportunities for citizens to participate in scientific investigations. Data from standard measurements made using NEON will be publicly available.



NEON will be a collaborative research platform of geographically distributed infrastructure connected via the latest information technology. By combining in-situ sensing with remote sensing observations, NEON will address pressing environmental questions on regional to continental scales. *Credit: NSF.*

Coordination with other federal agencies occurs through the NEON Federal Agency Coordinating Committee. Discussions have resulted in a signed Memorandum of Understanding (MOU) between NSF and the U.S. Geological Survey (USGS) that will facilitate the sharing of satellite remotely sensed data, in-situ verification, and archival storage of NEON aerial remote sensed data by USGS. Discussions are underway with NASA to partner on satellite remote sensing and ecological forecasting. Since a number of the NEON infrastructure deployment sites are located on USDA Forest Service lands, a draft agreement is under development for NEON to partner with Forest Service research stations, enable data exchange, and facilitate permitting at a national level. Discussions between NSF and Department of Energy (DOE) have focused on collaboration between NEON and DOE's Ameriflux network of sites. National Oceanic and Atmospheric Administration (NOAA) and NSF are discussing a partnership to use NEON sites as primary CO2 observation sites and to partner with NOAA's coastal observation initiative and the National Estuarine Research Reserve network. NOAA may also support NEON operations and measurements in sensitive coastal regions.

Private foundations, e.g., the Heinz Center, Nature Serve, and U.S. Landtrust, are participating in the NEON design, research, and development activities. While the bulk of NEON's infrastructure and instrumentation will be "commercial off the shelf", NEON's scientific and networking design requires certain technological innovations. Consequently, NEON has partnered with industry on R&D activities in the areas of sensors and cyberinfrastructure.

Project Report:

Management and Oversight:

- NSF Structure: The FY 2009 budget requests a realignment that will move NEON management and oversight from the Division of Biological Infrastructure to the Office of Emerging Frontiers. The realignment will strengthen management oversight of the project and foster its interdisciplinary science connections.

The project is managed by a Program Officer in Emerging Frontiers. The project is monitored closely by the Office of the Assistant Director/BIO where the BIO AD provides overall policy guidance and oversight. A Business Oversight Team chaired by the NEON Program Officer advises and assists the OAD/BIO on the business framework of the project. A BIO-NEON committee, which includes the BFA Deputy Director for Large Facility Projects, and a cross-NSF Program Advisory Team (PAT) formulates program planning for NEON.

- External Structure: The NEON Project is funded through cooperative agreements with NEON, Inc. The NEON, Inc.'s CEO provides overall leadership and management. A Project Manager at NEON, Inc. oversees all aspects of the project design, review, construction, and deployment. The NEON, Inc.'s Chief Technology Officer is responsible for oversight of the cyberinfrastructure and embedded sensor development. The NEON, Inc. Board of Directors, a Science, Technology, and Education Advisory Committee (STEAC) and a Program Advisory Committee (PAC), composed of members of the NEON user community help ensure that NEON will enable frontier research and education.

- Reviews:

  - Technical reviews: The NEON Integrated Science and Education Plan and Networking and Informatics plans were merit reviewed in FY 2006.
  - Management, Cost, and Schedule reviews:
    - The Conceptual Design Review (CDR) was conducted in November 2006.
    - A Preliminary Design Review (PDR) was held in May 2007. The review identified several issues that are currently being addressed by the project.
    - Cost and Schedule reviews: Scheduled for FY 2008
    - Readiness Review for Final Design Review scheduled for FY 2008.
    - Final Design Review scheduled for FY 2009.

<u>Current Project Status:</u>

The NEON, Inc. Project Office is currently completing the final NEON Project Execution Plan (PEP), addressing site selection and deployment issues, and beginning work on Environmental Compliance. They are finalizing the network design and addressing issues raised at the PDR in May 2007. A follow-up review of outstanding issues identified during the PDR will be held in FY 2008. In FY 2009 the final design and baseline, scope, schedule, and the risk-adjusted cost will be reviewed. Sufficient contingency will be built into the project design and budget to cover known risks.

<u>Cost and Schedule:</u>

FY 2008 MREFC funds will be carried over to FY 2009. In FY 2009, based on the outcome of the FDR, these MREFC funds will be used to begin construction of the first NEON Domain Core Site Fundamental Instrumentation Unit and embedded cyberinfrastructure. Prior to certification of construction-readiness following a final baseline review, support is requested through the R&RA account for the NEON Project Office, NEON, Inc, Consortium for oversight of the project, and ongoing R&D projects. The project will be eligible to receive additional MREFC funding for construction following successful completion of the Final Design Review.

<u>Risks:</u>

- Technical: Dependence on commercial off-the-shelf technology will be mitigated by long-lead purchase orders and alternative vendors. Production quality, embedded and system-level cyberinfrastructure (CI) will be addressed by a combination of "In-house" design, commercial, contracts, and targeted research (e.g., cyber-dashboard).

- Deployment: Environmental Assessment and permitting may impact schedule and costs. These risks are being addressed through the contracting of two national legal firms by NEON, Inc., having alternative sites if the primary sites have significant risk, US Forest Service allocating an FTE to assist with Environmental compliance issues on Forest Service lands, and the direct involvement of local staff scientists in site analysis and preparation.

- Remote Sensing: A potential risk is the long-term availability of satellite (e.g., LANDSAT and MODIS) borne sensors. This risk is mitigated through a partnership with the USGS EROS Data Center that has the federal responsibility for curation and management of LANDSAT and MODIS images and having alternative satellite sensor sources to purchase images (e.g., SPOT - France, AWIFS – India, Terra and Aqua - US). The proposed NEON Airborne Sensor System design and aircraft availability provide technical and implementation risk. To minimize this risk the Airborne Sensor System is being prototyped by NASA and Carnegie Mellon University and designed to fit multiple aircraft, including commercial aircraft. Design engineers from Carnegie Mellon University are contracted by NEON, Inc. and experienced research aircraft pilots serve on the design team.

<u>Future Operations Costs</u>

Management and Operations Costs are being refined in response to issues raised in the Preliminary Design Review and will be reviewed at both the Readiness and Final Design Reviews.

Ocean Observatories Initiative $0.0

No additional funds are requested for the Ocean Observatories Initiative through the MREFC account in FY 2009.

MREFC Funding for the Ocean Observatories Initiative
Appropriations and Requests
(Dollars in Millions)

	FY 2007 Appropriation	FY 2008 Estimate	FY 2009 Request
OOI Appropriations and Requests	5.12	5.91	-
Rescission	-5.12		
Total, OOI	-	$5.91	-

$5.12 million of the FY 2007 appropriated funds for OOI were rescinded per PL 110-161.

Baseline History: NSF first requested construction funding for OOI through the MREFC account in FY 2007 and received initial appropriations of $5.12 million in FY 2007. A robust project execution plan, refined cost estimates, and well-developed risk mitigation strategy are planned in FY 2009. A final design review will be held in FY 2008; if the review is successful, the project will be eligible for additional MREFC construction funding in a future budget request.

If constructed, the proposed OOI would consist of an integrated observatory network that will provide the oceanographic research and education communities with continuous, interactive access to the ocean. The OOI would have three elements: 1) deep-sea buoys with designs capable of deployment in harsh environments such as the Southern Ocean; 2) a regional electro-optical cabled network on the seafloor spanning several geological and oceanographic features and processes; and 3) an expanded network of coastal observatories. A cutting edge, user-enabling cyberinfrastructure would link the three components of the OOI and facilitate experimentation using assets from the entire OOI network.

The Preliminary Design Review (PDR) was held December 4-7, 2007. The review panel found that OOI planning had progressed to the point that the project was essentially construction ready, but noted some minor outstanding issues for resolution by the project.

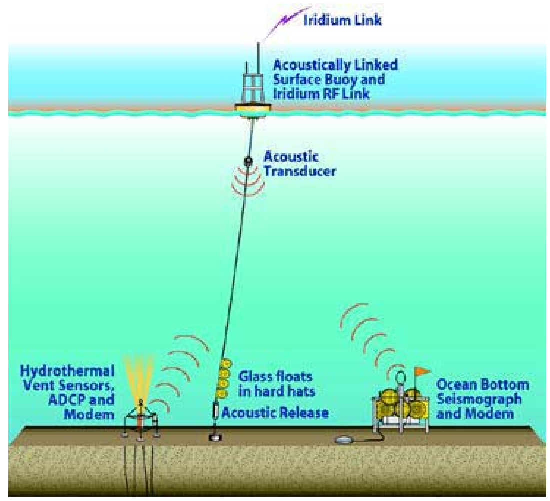
Total Obligations for the OOI
(Dollars in Millions)

	Prior Years	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
R&RA Obligations:									
Concept & Development	43.07	6.49	9.00	10.50	-				
Management and Operations	-								
Subtotal, R&RA Obligations	$43.07	$6.49	$9.00	$10.50	-	-	-	-	-
MREFC Obligations:									
Implementation	-	-	5.91	-					
Subtotal, MREFC Obligations	-	-	$5.91	-	-	-	-	-	-
Total: OOI Obligations	**$43.07**	**$6.49**	**$14.91**	**$10.50**	**-**	**-**	**-**	**-**	**-**

Once established, seafloor observatories will provide earth, atmospheric, and ocean scientists with unique opportunities to study multiple, interrelated processes over timescales ranging from seconds to decades; to conduct comparative studies of regional processes and spatial characteristics; and to map whole-earth and basin scale structures. Scientific discoveries arising from the OOI will provide new opportunities for ocean education and outreach through the capabilities for real-time data transmission and, particularly, real-time display of visual images from the seafloor. Desktop participation in oceanographic experiments will revolutionize access to the sea for students, educators and the general public. Educational links will be made with the Division of Ocean Sciences (OCE) Centers for Ocean Science Education Excellence (COSEE). In addition, with the planned establishment of the National Integrated Ocean Observing System (IOOS), there will be an unprecedented need for a STEM workforce and oceanographers skilled in the use and manipulation of large, oceanographic, time-series datasets. The facilities comprising the OOI will provide the ideal platforms to train this new generation of oceanographers.

Some of the component technologies that are part of the OOI are currently in use or in development as part of the telecommunication and exploration industries. These groups were involved in drafting the OOI Conceptual and Preliminary Network Designs as well as in reviews of OOI planning. Industry will also be important participants in the construction and implementation phase of the OOI as well as in the future development of sensors critical to the evolution of the OOI network.

Science proposals using the OOI network will be solicited as part of the normal competition for funds in the Division of Ocean Sciences. The research envisioned for the OOI encompasses a broad range of disciplines, and therefore no special research program will be established. Instead proposals will be reviewed and competed alongside all other research proposals submitted to OCE.



Pictured here is an artist's rendition of a a low-bandwidth discus buoy system that uses acoustic modems to transfer data intermittently from instruments on the seafloor or mooring to a surface buoy, and from there to shore via a low-power, omnidirectional satellite system. *Credit: DEOS Buoy Design Study, ORION.*

Project Report:

Management and oversight:

- NSF Structure: The project is managed and overseen by a program manager in OCE (in GEO). The program manager receives advice and oversight support from an NSF PAT that includes representatives from GEO, BIO, ENG; BFA; OISE; OGC; and OLPA. The BFA DDLFP is a member of the PAT and provides advice and assistance.

- External Structure: In the management structure for the construction phase of OOI, management, coordination, and oversight of the OOI will be the responsibility of the OOI Project Director operating from the Ocean Observatory Project Office at the Consortium for Ocean Leadership (Ocean Leadership) established through a cooperative agreement with NSF in 2004. This Project Director will be accountable to an external advisory structure consisting of scientific and technical advisory committees. Advisory committee membership will be drawn from individuals with expertise in ocean observing science and engineering. Subawards have been issued by Ocean Leadership, which houses the OOI Project Office, to establish three Implementing Organizations (IOs). These IOs will provide the detailed management and oversight for implementation the regional cabled observatory (led by the University of Washington), cyberinfrastructure (led by the University of California-San

Diego/Scripps Institute of Oceanography), and coastal/global observatories (led by Woods Hole Oceanographic Institution). These IOs will report directly to the Project Office, which will ensure cooperation and coordination between the IOs. The OOI will be coordinated with the IOOS that will support operational mission objectives of agencies such as the National Oceanic and Atmospheric Administration (NOAA), the U.S. Navy, the National Aeronautics and Space Administration (NASA), and the U.S. Coast Guard.

- Reviews:

  - Technical reviews: NSF has organized a series of external science reviews for the OOI including the Blue Ribbon Science Review (July 2006) which assessed whether the ocean observing network proposed in the OOI Conceptual Network Design (CND) would provide the capabilities for the ocean researchers to answer high priority science questions that require in situ, real-time measurements across the three scales of the OOI; and a second Blue Ribbon review (October 2007), which assessed whether the OOI PND provided the experimental capabilities needed to address the scientific scope outlined for the OOI. These science reviews provided a general endorsement of the OOI, supplemented by a series of recommendations for improvement; these reviews also served as input to the PDR.

  - Management, Cost, and Schedule reviews:
    - The OOI CDR, held August 2006, reviewed the scope and system level implementation plans for the OOI, including management plans and budgeting, and discussed whether all major risks with this project have been identified and whether appropriate initial system development specifications (performance requirements, major system components, and interfaces) have been established for each sub-element of the OOI
    - The PDR in December 2007 assessed the robustness of the technical design and completeness of the budget and construction planning for the OOI. The PDR panel also reviewed progress made by the OOI Project Team on the findings of the CDR.

  - Upcoming reviews:
    - A Final Design Review (FDR) is planed for October 2008 to determine the readiness of OOI design, execution plans, and risk analyses for full construction and establish the baseline for the OOI.
    - A cost review will be held after NSB approval for construction start and prior to the beginning of construction effort.

Current Project Status:

Informed by the December 2007 Preliminary Design Review, the OOI Project Office and Implementing Organizations are in the process of finalizing the network design, project execution plan, and risk analyses.

Cost and Schedule:

Project cost will be accurately determined at the Final Design Review and updated at subsequent cost reviews as needed.

Risks:

- Oversight risk: Although the lead organization (JOID) has experience integrating less complex projects, the complexity of the OOI and the need for the project teams to integrate amongst themselves and with the Project Office, and work effectively within the OOI Project Team under the schedule, cost, and scope constraints of the project presents a significant project risk. The OOI relies heavily on open lines of communication and effective cooperation between the managing entities (Project Office and IOs) and NSF. To mitigate this risk, monthly, quarterly and annual reports from the Project Office and IOs will be closely monitored by the OOI Program Manager and Contracts Officer for deviations from established baselines and annual site visits and reviews will be used to gain a more detailed impression of the integrative nature of the project teams. In addition, weekly teleconferences with the program staff from both the Project Office and IOs will help ensure that all groups are up to date with current activities. OOI programmatic reviews, conducted by NSF, and rotating internal reviews of the IOs (with external participation) will be performed annually, in addition to assessments by an external scientific oversight committee. Lastly, NSF's OOI Program Director will attend internal OOI project reviews being held by the Project Office to ensure that oversight of OOI implementation is proceeding according to established principles as outlined in the Cooperative Agreement with JOID and by agreement at baseline reviews.

- Scope contingency: The project team has been directed to develop an appropriate level of contingency for the OOI as dictated by a comprehensive risk analysis. Should this contingency be exhausted, reductions in the scope of the OOI network plan will be required. These potential reductions, or scope contingency, must be implemented based on clearly articulated scientific priorities. Any changes to scope (as well as cost or schedule) will follow the Change Control Process, which has a tiered evaluation process for evaluating and determining any change to the project.

- Procurement Risk: Procurement delays for the OOI resulting from improper contracting methods or lack of oversight could impact the OOI scope, budget and schedule. To mitigate these risks, project acquisition plans, subawards and subcontracting strategies for each major work breakdown structure (WBS) element will be reviewed by a panel of experts prior to dispensing MREFC funds for OOI during the FDR. In addition, NSF will draft a special term and condition for inclusion in the Ocean Leadership Cooperative Agreement that requires the JOI to submit an annual procurement plan to NSF for review. The OOI Business Oversight Team will work jointly with the JOI to review critical procurements and ensure that project delays are minimized through appropriate procurement strategies.

- Technical Risk: Some aspects of the OOI network design have yet to undergo extensive field-testing and, therefore, delays in acceptance and commissioning of these elements could impact the overall project schedule and budget. Much of this testing will be the responsibility of the Implementing Organizations and, therefore, is dependent on the time needed for them to become fully established entities. To mitigate risks resulting from technical readiness, the Project Office will conduct system engineering and readiness reviews of all critical new technologies.

- Risks Related to the OOI Cyberinfrastructure - The OOI cyberinfrastructure will not only provide the network integration needed to achieve the scientific goals of the OOI, a robust, user-friendly cyberinfrastructure will be essential to develop a vigorous OOI user community. Delays in development of the OOI cyberinfrastructure, or development of a system that does not serve user needs, will greatly impact successful implementation of the OOI network. Both the OOI cyberinfrastructure network architecture and the selection of the cyberinfrastructure Implementation Organization were completed with significant input from Program Officers in the Office of

Cyberinfrastructure (OCI). Continued involvement of OCI Program Managers, via the PAT and participation in reviews of the OOI network, will be critical to mitigate risks associated with establishment of the OOI data management and acquisition system.

Future Operations Costs:

A steady state of $50.0 million in operations support (2013 dollars) is anticipated, and the expected operational lifespan of this project is 30 years.

South Pole Station Modernization **$0.00**

FY 2008 represented the final year of appropriations for the South Pole Station Modernization (SPSM) project; no funds are requested in FY 2009. Construction continues through FY 2010.

MREFC Funding for the South Pole Modernization Project
Appropriations and Requests
(Dollars in Millions)

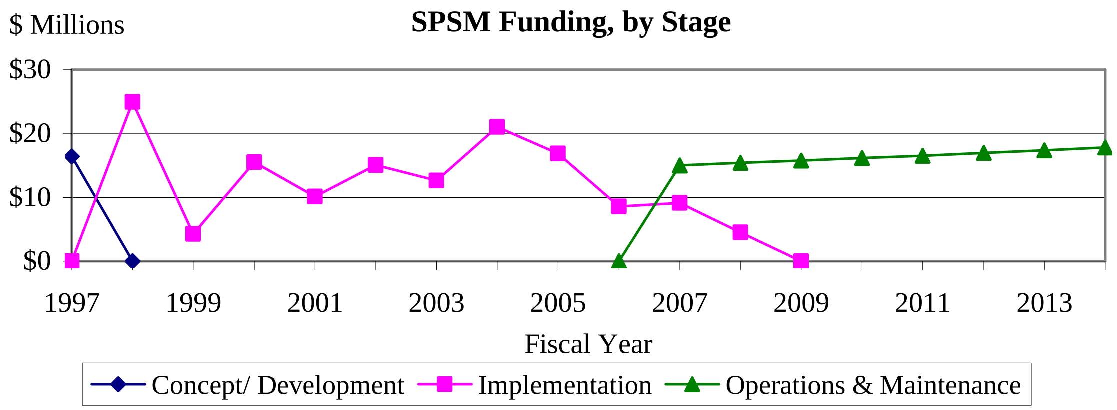
	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07 Actual	FY08 Est	FY09 Req	Total
Appropriations	$70.00	$39.00	$5.40	$13.47	-	$5.96	$1.29	-	-	$9.13	$6.55	-	$150.80
Reprogramming				-$1.00	-$0.50	-$0.24			$0.23				-$1.51
	$70.00	$39.00	$5.40	$12.47	-$0.50	$5.73	$1.29	-	$0.23	$9.13	$6.55	-	$149.29

NSF reprogrammed $1.0 million in FY 2001 to the Polar Support Aircraft Upgrades, $500,000 in FY 2002 to the South Pole Safety and Environmental project, and $235,000 in FY 2003 to HIAPER and LHC to cover final costs due to a rescission in that year. The FY 2004 appropriation for SPSM represents payback for the reprogrammings in FY 2001 and FY 2003. SPSM received $120,000 of available funds in FY 2006 from the Polar Support Aircraft Upgrades upon completion of that project, and $110,000 from other MREFC projects.

Baseline History: NSF first requested and received funds to modernize the South Pole station in FY 1998, and the total cost was estimated at that time to be $127.90 million. In FY 2001, the National Science Board approved a change in project scope, increasing station capacity from 110 people to 150 people, as well as a change to the project schedule, extending it due almost entirely to weather-imposed logistics delays. These changes increased the cost estimate to $133.44 million. In FY 2007, following an internal review of the remaining scope of the project, NSF requested an additional $9.13 million to continue the project, bringing the estimate at completion to $142.74 million; the possibility that final completion might require additional funding beyond this amount was noted at that time. Following a full external review of the remaining scope of the project conducted by a team of experts, OPP prepared a revised SPSM cost and schedule, taking into account several risk factors of concern to the review panel such as competition for skilled construction workers with reconstruction activities in Iraq and post-Katrina Louisiana and Alabama; weather uncertainties; and scientific projects competing for limited logistics capabilities. These and other risk factors were incorporated into associated contingency funds and added $6.55 million to the project cost, bringing the total current estimate to $149.29 million. The revised schedule calls for the project to be completed in 2010. As of FY 2006, U.S. Antarctic Program participants have full use of the modernized station. The new station was dedicated in January 2008.

SPSM provides a new station to replace the current U.S. station at the South Pole, built 30 years ago and inadequate in terms of capacity, efficiency, and safety. The new station is an elevated complex with two connected buildings, supporting 150 people in the summer and 50 people in the winter.

The recently dedicated South Pole Stations. *Credit: NSF*



Total Obligations for SPSM
(Dollars in Millions)

	Prior Years	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
R&RA Obligations:									
Concept & Development	16.40	-							
Management and Operations		15.00	15.38	15.76	16.14	16.53	16.94	17.38	17.81
Subtotal, R&RA Obligations	$16.40	$15.00	$15.38	$15.76	$16.14	$16.53	$16.94	$17.38	$17.81
MREFC Obligations:									
Implementation	133.47	6.19	6.55	3.08	-				
Subtotal, MREFC Obligations	$133.47	$6.19	$6.55	$3.08	-	-	-	-	-
Total	**$149.87**	**$21.19**	**$21.93**	**$18.84**	**$16.14**	**$16.53**	**$16.94**	**$17.38**	**$17.81**

The funds identified in the FY 2009 Request column, $3.08 million, are carryover funds from previous years. NSF expects to fully obligate MREFC funding for SPSM in FY 2009.

The prime contractor for the U.S. Antarctic Program is responsible for constructing the South Pole Station. In addition, there are approximately 385 separate subcontractors for supplies and technical services.

The completed South Pole Station will provide a platform for the conduct of science at the South Pole and fulfills NSF's mandate to maintain a continuous U.S. presence at the South Pole in accordance with U.S. policy.

NSF will also support education associated with the research projects at the South Pole. Along with direct operations and maintenance support for South Pole Station, NSF will support science and engineering research through ongoing programs. The annual support for such activities is currently estimated to be approximately $9.5 million.

Project Report:

<u>Management and Oversight:</u>

- NSF Structure: OPP has the overall oversight responsibility for SPSM, including development of the basic requirements, design, procurement, and construction. The project status, including cost expenditures and cost projections, is monitored closely by the OPP Facilities Engineer and other OPP staff, and on a periodic basis by the project's Project Advisory Team, a group of experts drawn from all relevant NSF Directorates and Offices.

- External Structure: NSF has contracted for procurement and construction management for all phases of the project, including design reviews of all drawings and specifications; conformance of the designs and procurements with established standardization criteria; assistance in establishing functional interfaces; transition from the existing to the new facilities; and systems integration. Naval Facilities Engineering Command, Pacific Division (PACDIV) selects, monitors, and manages architectural and engineering firms for design, post-construction services, and construction inspection for the project.

- Reviews: Design, development, planning, and closely related activities in support of this project included preparation of more than 40 engineering studies and reports. The documents ranged widely in subject matter including subjects such as snowdrift minimization modeling, detailed analysis of power and heating requirements, preparation of a draft Environmental Impact Statement, energy conservation measures, efficiency and maintainability of diesel generators, fuel storage support system evaluation, design code criteria matrix, concept for signal/communication systems, gray-water system evaluation, minimization of ventilation requirements, control of diesel engine exhaust emissions, and jacking plan and concept.

The OPP Facilities Engineer, other OPP and NSF staff, and subject matter experts attend quarterly reviews at the contractor's facility for the purpose of reviewing all aspects of the project including cost, schedule, and plans. In September 2006, an external panel of experts reviewed the scope, cost, schedule, and effectiveness of management processes to complete the final 10 percent of the project. As a result, the project's baseline was increased to $149.29 million.

<u>Current Project Status:</u>

- Tasking Completed in FY 2007:
  - Construction of Cryogens Facility
  - Siding and chamfer panels on Elevated Station Pod A
  - Initiated construction of Water Well #3
  - Demolition – Science/Upper Berthing, Old Garage Shop, Comms/Ops/Store
  - Elevated Station Controls Balancing
  - IT Systems – SPTR-1 Upgrades, Commercial Global, Station Operations Center
  - Elevated Station Punch list

<u>Cost and Schedule:</u>

SPSM scope is slightly over 90% complete, with the elevated station and all science facilities in full use. Project cost performance index (CPI) and schedule performance index (SPI) are presently ranked green, indicating variances are within 10 percent, and current forecasts show the project completing on schedule. The project is currently over budget and ahead of schedule, with a cost performance index of 97.6 percent and a schedule performance index of 100.5 percent as of October 2007 financial data. Available contingency is approximately 10 percent of remaining costs.

- Tasking Scheduled for FY 2008:
  - Initiate construction of Logistics/Warehousing Facility
  - Complete Water Well #3

- Demolition – Old Power Plant, Dome Entry Arch
- Siding and chamfer panels on Elevated Station Pod B
- IT Systems Closeout – Telephone Systems/Network Backbone, Network Management, CCTV System

- Tasking Scheduled for FY 2009:
  - Conditional Acceptance of Logistics/Warehousing Facility
  - Completion of Siding Pod A
  - Begin Dome Demolition
  - Aircraft Fueling Module

- These are the current milestones:

Activity	**Procurement**	**Transport to Antarctica**	**Airlift to South Pole**	**Start Construction**	**Conditional Acceptance**
Vertical Circular Tower	FY98	FY99	FY99/00	FY00	FY02
Quarters/Galley	FY98	FY99	FY00/FY01	FY01	FY03
Sewer Outfall	FY98	FY99	FY00	FY01	FY02
Fuel Storage (100K gallons)	FY98	FY98	FY99	FY99	FY99
Medical/Science	FY99	FY00	FY01/02	FY02	FY04
Communications/Administration	FY99	FY01	FY02/03	FY03	FY06
Dark Sector Lab	FY98	FY99	FY99/00	FY00	FY06
Water Well	FY00	FY01	FY01/02	FY02	FY08
Remote RF Building	FY99	FY00	FY01	FY01	FY01
Emergency Power/Quarters	FY99	FY01	FY02/03	FY03	FY05
Liquid nitrogen and helium facility	FY02	FY03	FY04	FY04	FY07
Quarters/Multipurpose	FY99	FY02	FY04	FY05	FY06
Electronic Systems and Communications	FY00/03	FY01/04	FY01/05	FY01	FY06
Warehousing, SEH and Waste Management	FY99	FY02/03	FY04/05/06	FY07	FY09
Station Equipment	FY02/03	FY03/04	FY04/05	N/A	FY10

<u>Risks:</u>

Project performance could be affected if a full construction crew cannot be maintained for the remaining scope. Additional high impact risk elements to project completion include equipment failure, damaged materials, unforeseen downtime from power failures, inclement weather, and widespread illness – all of which have occurred to varying degrees. Risk management is ongoing and has produced multiple sets of back-up strategies to employ in the face of identified concerns.

<u>Future Operations Costs:</u>

Operational costs of the modernized station are expected to be higher than operational costs of the current station due to increased station size and increases in Science Support and Information Systems. A steady state of operational support is anticipated at $15.0 million, excluding inflation. The expected lifetime of the modernized station is 25 years, through FY 2031. These estimates are currently being reviewed to improve accuracy, taking into account estimated station population and cargo loads.

NEW MREFC FUNDING REQUESTED IN FY 2009:

The Advanced Technology Solar Telescope $2,500,000

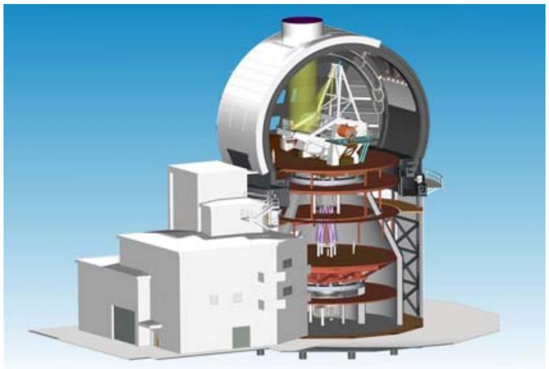
The FY 2009 Budget Request for the Advanced Technology Solar Telescope (ATST) is $2.50 million to support design activities. The use of these funds will require a determination by the NSF Director – in consultation with the National Science Board (NSB) – that these funds are necessary to complete a construction-ready design. The use of MREFC funding for design and other pre-construction activities is a principal focus of ongoing reviews of NSF's MREFC processes by NSF management and the NSB.

MREFC Funding for the Advanced Technology Solar Telescope
(Dollars in Millions)

FY 2007 Appropriation	FY 2008 Estimate	FY 2009 Request
-	-	$2.50

If a decision is ultimately taken to proceed to the construction phase, ATST will enable the study of magneto-hydrodynamic phenomena in the solar photosphere, chromosphere, and corona. Determining the role of magnetic fields in the outer regions of the Sun is crucial to understanding the solar dynamo, solar variability, and solar activity, including flares and mass ejections which can affect civil life on earth and may have impact on the terrestrial climate.

Beginning in 2001, NSF has provided funds to the National Solar Observatory (NSO) for an eight-year design and development program for the ATST and its first-light instruments through the Division of Astronomical Sciences and the Division of Atmospheric Sciences. The ATST project is a collaboration of scientists and engineers at more than 20 U.S. and international organizations. Potential partners include the Air Force Office of Scientific Research and international agencies and groups in Germany, the United Kingdom, Italy, Canada, and the Scandinavian countries.



An artist's rendition of the ATST.

The current ATST design, cost, schedule, and risk were scrutinized in an NSF-conducted preliminary design review in October-November 2006. A critical design review will be conducted in mid-2008, followed by a baseline review in the spring of 2009.

Project Report

Management and Oversight

- NSF Structure: Oversight from NSF is by a program manager in the Division of Astronomical Sciences in the Directorate of Mathematical and Physical Sciences working with staff from the Offices of the Deputy Director for Large Facilities, General Counsel, and Legislative and Public Affairs, and the Division of Atmospheric Sciences in the Directorate for Geosciences.

- External Structure: The ATST Project is managed by the NSO. NSO operation and maintenance and the ATST design and development is funded by NSF via a cooperative agreement with the

Association of Universities for Research in Astronomy, Inc. The NSO Director serves as the Director of the ATST project; a senior NSO scientist is the Project Scientist; and an experienced full-time Project Manager coordinates the Project activities. Several councils and working groups provide input from the solar and space physics communities.

- Reviews:
  - Technical Reviews: Reviews have been conducted throughout the design and development phase. The preliminary design was found to be robust in an NSF-conducted Preliminary Design Review in October-November 2006. The Project is currently completing a comprehensive set of system-level design reviews for all major sub-systems.
  - Management, Cost, and Schedule Reviews: The ATST cost, schedule and risk were scrutinized and validated at the Preliminary Design Review.
  - Upcoming Reviews: A critical design review is planned for mid-2008, followed by a baseline review in the spring of 2009.

Current Project Status

Current activities include finalizing the design and retiring the remaining areas of risk. The project has chosen the Haleakala High Altitude Observatory on the island of Maui as the site for the ATST. Preparation of the environmental impact statement is in its final stages. Consultation with Native Hawaiian stakeholders is ongoing. Application for the final construction permits required for the ATST site will follow the publication of a record of decision. An allocation of $2.50 million in FY 2009 will allow the project to contract for detailed designs of critical-path systems, notably for the building and telescope pier foundations.

STEWARDSHIP

The NSF Strategic Plan for FY 2006-2011 defines Stewardship, the Foundation's fourth strategic goal along with the other strategic goals (Discovery, Learning, and Research Infrastructure), as supporting excellence in science and engineering research and education through a capable and responsible organization. Excellence in NSF's stewardship is essential to achieving the Foundation's mission and accomplishing its goals.

The activities that advance NSF's Stewardship goal are funded through five appropriations accounts. Additional details on each account are provided in the respective chapters.

Agency Operations and Award Management (AOAM) increases by $23.27 million, or 8.3 percent, to $305.06 million in FY 2009. These resources include funding for personnel compensation and benefits, information technology (IT) that supports administrative activities, staff travel, training, rent, and other operating expenses necessary for effective management of NSF's research and education activities.

Office of Inspector General (OIG) increases by $1.67 million, or 14.6 percent, to $13.10 million in FY 2009. These resources include funding for personnel compensation and benefits, contract audits, training and operational travel, office supplies, materials, and equipment.

National Science Board (NSB) increases $61,000 in FY 2009, or 1.5 percent, to $4.03 million in FY 2009. These resources include funding for personnel compensation and benefits, contracts, training and operational travel, office supplies, materials, and equipment.

Program Accounts - Research and Related Activities (R&RA) and **Education and Human Resources** (EHR) - increase by $20.26 million, or 32.8 percent, to $82.12 million in FY 2009. Stewardship costs directly related to programs are funded within R&RA and EHR. Direct program Stewardship activities include funding for Intergovernmental Personnel Act (IPA) agreements and certain Foundation-wide activities such as major studies, evaluations, outreach efforts, information technology investments that are directly related to the mission of the Foundation, and NSF contributions to interagency e-Government activities.

Stewardship by Appropriations Account

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Agency Operations and Award Management	$248.49	$281.79	$305.06	$23.27	8.3%
Office of Inspector General	11.92	11.43	13.10	1.67	14.6%
National Science Board	3.65	3.97	4.03	0.06	1.5%
R&RA Appropriation	48.77	52.42	70.27	17.85	34.1%
EHR Appropriation	7.24	9.44	11.83	2.39	25.3%
Subtotal, Program Support	56.01	61.86	82.10	20.24	32.7%
Total	$320.07	$359.05	$404.29	$45.24	12.6%

Totals may not add due to rounding

NSF Workforce
Full-Time Equivalents (FTE)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
AOAM FTE Allocation					
Regular	*1,248*	*1,270*	*1,295*	*25*	*2.0%*
Student	*35*	*40*	*40*	*-*	*-*
Subtotal, AOAM FTE Allocation	*1,283*	*1,310*	*1,335*	*25*	*1.9%*
AOAM FTE Usage (Actual/Projected)					
NSF Regular	1,196	1,240	1,280	40	3.2%
NSF Student	32	40	40	-	-
Subtotal, AOAM FTE[1]	1,228	1,280	1,320	40	3.1%
Office of the Inspector General[2]	67	63	64	1	1.6%
National Science Board[3]	15	14	14	-	-
Arctic Research Commission[4]	5	4	4	-	-
Total, Federal Employees	1,315	1,361	1,402	41	3.0%
IPAs	167	170	195	25	14.7%
Detailees to NSF	3	6	6	-	-
Contractors (est.)	370	430	480	50	11.6%
Total, Workforce	1,855	1,967	2,083	116	5.9%

[1]Additional information regarding FTEs funded through the AOAM appropriation are available in the AOAM chapter.
[2]The Office of Inspector General is described in a separate chapter and is funded through a separate appropriation.
[3]The National Science Board is described in a separate chapter and is funded through a separate appropriation.
[4]The U.S. Arctic Research Commission is described in a separate chapter and is funded through the R&RA appropriation.

The staffing profile in the table above shows that a small but significant percentage of the NSF workforce – 170-180 people or about 10 percent – consists of temporary employees hired through the authority provided by the IPA. IPAs do not count as federal FTE. A smaller number of visiting staff – roughly 40 people annually – are employed through NSF's own Visiting Scientist, Engineer, and Educator Program (VSEE). VSEEs count as federal FTE and are included in the *Federal Employees* total (see table above). The use of IPAs and VSEEs, commonly referred to as rotators, has been a defining characteristic of NSF since its inception in 1950.

IPAs are considered federal employees for many purposes during their time at NSF, even though they remain employees of their home institutions. They are not paid directly by NSF and are not subject to federal pay benefits and limitations. NSF reimburses the home institution for the IPA's salary and benefits using the traditional grant mechanism. IPAs are also eligible to receive *per diem*, relocation expenses, and reimbursement for any income foregone because of their assignment at NSF (i.e., lost consulting fees). VSEEs, by contrast, receive a salary directly from NSF (through the AOAM appropriation), although they continue to receive benefits through their home institutions, which are reimbursed by NSF.

While at NSF, rotators function in a manner virtually identical to the Foundation's permanent staff – leading the merit review process, overseeing awards, and shaping future program directions. To smooth their transition and help them quickly assimilate their responsibilities at NSF, the NSF Academy organizes intensive training activities, including a three-day, off-site program management seminar offered several times each year for new rotators and permanent staff.

R&RA and EHR Program Support funds account for roughly 20 percent of the total Stewardship portfolio. More detailed information on the Program Support costs is shown in the tables below. The first table identifies the two cost elements of Program Support.

Summary of Program Support Costs
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
IPA Costs	$29.40	$32.42	$37.42	$5.00	15.4%
Program Related Administration	26.61	29.44	44.68	15.24	51.8%
Program Related Technology	*16.24*	*20.00*	*37.10*	*17.10*	*85.5%*
Other Program Related Administration	*10.37*	*9.44*	*7.58*	*-1.86*	*-19.7%*
Total, Program Support Costs	$56.01	$61.86	$82.10	$20.24	32.7%

Totals may not add due to rounding.

IPA Costs

The following table breaks down the IPA costs by appropriation into basic compensation, travel, and other benefits.

IPA Costs by Appropriation
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
R&RA					
IPA Compensation	$20.91	$21.51	$24.99	$3.48	16.2%
IPA Lost Consultant & Per Diem	2.22	2.29	2.66	0.37	16.2%
IPA Travel	3.02	3.09	3.59	0.50	16.2%
Subtotal, R&RA Costs	26.15	26.89	31.24	4.35	16.2%
EHR					
IPA Compensation	2.57	4.37	4.88	0.51	11.7%
IPA Lost Consultant & Per Diem	0.47	0.80	0.87	0.07	8.7%
IPA Travel	0.21	0.36	0.43	0.07	19.4%
Subtotal, EHR Costs	3.25	5.53	6.18	0.65	11.8%
Total, IPA Costs	$29.40	$32.42	$37.42	$5.00	15.4%

Totals may not add due to rounding.

Program Related Administration

Program Related Administration includes funding for certain Foundation-wide activities such as major studies, evaluations, outreach efforts, NSF contributions to interagency e-Government activities, and grants management applications that benefit the research community, such as a reviewer management system to more effectively plan for, and find, thousands of scientific experts required to support the merit review process.

Program Related Technology

NSF is dedicated to the support of fundamental research across all fields of science and engineering (with the exception of medical science) and all levels of science and engineering education. NSF fulfills its mission by issuing grants to fund specific research proposals that have been judged the most promising by a rigorous and objective merit-review system. With this single mission focus, program related information technology (IT) investments are critical to supporting science and engineering research and education activities within the Foundation.

In FY 2009 NSF will begin transitioning the funding for mission-related IT investments from the AOAM account to the program account (R&RA and EHR). IT investments funded with AOAM resources will support routine administrative activities, such as human resources, financial statement preparation, property, procurement, etc. Program Related Technology resources will fund information technology activities which relate directly to the work of the programs, such as Research.gov, eJacket, FastLane, and Reviewer Management. NSF has previously included limited funding for program-related IT investments, such as FastLane, under Program Related Administration. Funding was included to initiate Research.gov in FY 2008.

Information Technology (IT) Investments by Appropriation
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Agency Operations and Award Management	$34.82	$42.18	$45.08	$2.90	6.9%
Program Related Technology	16.24	20.00	37.10	17.10	85.5%
R&RA	*13.80*	*17.40*	*32.28*	*14.88*	*85.5%*
EHR	*2.44*	*2.60*	*4.82*	*2.22*	*85.4%*
Total	$51.06	$62.18	$82.18	$20.00	32.2%

Totals may not add due to rounding

Information Technology (IT) Investments
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Agency Operations and Award Management					
Administrative Applications Services and Support	$16.27	$19.88	$19.03	-$0.85	-4.3%
Associated Infrastructure Services and Support	16.10	18.33	22.94	4.61	25.2%
Security and Privacy Services and Support	2.45	3.97	3.11	-0.86	-21.7%
Subtotal, AO&AM	$34.82	$42.18	$45.08	$2.90	6.9%
Program Related Technology					
Mission-Support Applications Services	14.74	18.00	35.10	17.10	95.0%
Related Security and Privacy Services	1.50	2.00	2.00	-	-
Subtotal, Stewardship	$16.24	$20.00	$37.10	$17.10	85.5%
Total, Information Technology Investments	$51.06	$62.18	$82.18	$20.00	32.2%

Totals may not add due to rounding

Program-related IT investments support NSF program staff as they formulate and announce program opportunities; accept proposals; conduct the merit review process; make awards to fund proposals that have been judged the most promising by the rigorous and objective merit-review process; monitor program performance and results; and disseminate results of NSF funded research.

To assure that critical, program-related investments are appropriately acquired/developed, maintained, protected, and funded out of the account that corresponds to the customer being served, the FY 2009 Request initiates the transition of funding to program accounts for IT investments that are directly mission related, including the related support services necessary to operate these investments (e.g. training, customer support, maintenance, security, and privacy). This approach also gives customers a stronger financial incentive to drive the requirements for IT systems, consistent with best practices in industry and other federal agencies. IT investments that support routine administrative functions, such as financial statement preparation, human resources, and other administrative applications, will continue to be funded out of AOAM.

Summary of Major Changes

Funding for information technology increases by $20.0 million to a total of $82.18 million, a 32.2 percent increase over the FY 2008 Request. The major components of this increased investment are:

- $2.9 million increase in AOAM funding for IT to $45.08 million. The major components of this change include:
    - An increase of $4.61 million for Associated Infrastructure Services and Support for a total of $22.94 million. This funding level will permit the Foundation to implement key infrastructure maintenance and operations initiatives, including deploying the next generation network, hosting business applications on a modern technology platform, modernizing email redundancy and archiving capabilities, and providing additional remote access capabilities to support and increase the productivity of teleworkers and traveling staff (see AOAM section for more detail).
    - Offsets result from the realignment of mission-related IT functions in AOAM to program funding, including a $850,000 transfer for applications services and a $860,000 transfer for security and privacy services and support.

- $17.1 million increase in Program Related Technology for a total of $37.10 million. The major components of this change include:
    - $3.0 million increase for Reviewer Management, a new initiative to enhance the Foundation's capability to support the merit review process by providing better information and tools for finding reviewers and supporting the review process.
    - $6.8 million increase for the eJacket and Awards systems to improve capabilities for NSF program staff to perform critical actions to make awards to grantees and upgrade the current legacy Award system to a web-based environment.
    - $7.3 million increase for maintenance of critical mission applications and services such as FastLane. This increase primarily represents the shift of funding for mission-related IT investments and related support services from AOAM to Program funding.

In addition to these increases, $10.0 million will be used to continue Research.gov, which provides a menu of grants management services and information tailored to the needs of the research community; this includes $500,000 to support compliance with Section 207(g) of the E-Government Act of 2002, which requires public access to federally funded research and development information. Another $2.0 million is included to secure applications and protect sensitive program information. FY 2009 funding also includes planning funds for developing the business case for improved financial management capabilities.

Other Program Related Administration

Other Program Related Administration includes funding for Foundation-wide activities such as major studies, evaluations, and NSF contributions to interagency e-Government activities. These funds provide resources for activities such as: the GPRA verification and validation evaluation; the survey of scientists, engineers, and educators who submit proposals for NSF awards; Waterman Award which recognizes an outstanding young researcher in any field of science or engineering supported by NSF; Science and Technology Centers evaluation; Major Research Infrastructure evaluation; and AAAS fellowship program and internships. The decline reflects the net effect of shifting $4.0 million for outreach to the communicating science line in Integrated Activities' budget line of the R&RA appropriation.

Mission-Critical IT-based Business Processes

The mission related functions and enabling technology described in this section are:

- Supporting Proposal Solicitation, Submission and Management
- Facilitating the Merit-Based Proposal Review and Evaluation Process
- Supporting Proposal Processing and Award Management
- Enabling Public Dissemination of Research Information and Results
- Enhancing Management of Program Operations

Supporting Proposal Solicitation, Submission and Management

The Foundation considers proposals submitted by organizations on behalf of individuals or groups for support in most fields of research. Through electronic capabilities, NSF program staff create and collaborate on funding opportunities, management plans, and program budgets using an automated work flow. These opportunities are then published to NSF's website and Grants.gov to ensure potential applicants can easily find funding opportunities and information needed to submit proposals to NSF.

Over 250,000 scientists, educators, technology experts, and administrators including the nation's top researchers use FastLane to conduct business with NSF. Proposers use FastLane to prepare, view, modify, and submit proposals online. In FY 2007 alone, FastLane, NSF's web-based external grants management system, successfully supported the electronic submission and processing of more than 44,000 proposals.

While NSF has achieved unprecedented success with FastLane, the system was built starting in 1994 and is in need of a major modernization. NSF is modernizing FastLane through Research.gov, a new web portal that provides a menu of services tailored to the needs of the research community. Research.gov allows NSF to continue its leadership role and commitment to the broader research community by leveraging its FastLane capabilities to deliver a single web portal for research institutions to find relevant information and conduct grants business with federal research agencies.

Research.gov aligns with NSF's research mission and will be delivered in a modular and research community-focused manner. This measured, modular approach allows functionality to grow at the pace NSF and the community can fund and integrate into established business practices. Research.gov will provide a menu of services focused on the needs of research institutions. For example, Research.gov provides the ability for Sponsored Projects Offices and Principal Investigators (PIs) to check the status of their proposals as they are received and reviewed by NSF, and view a history of their submissions, panel summaries and reviews (PIs only), and award notices. Additional planned capabilities for FY 2008 and FY 2009 include an integrated web portal with single sign on capability, a grants policy library, research news and highlights, research spending and results, and online capabilities related to submission of grant financial and progress/project reports.

Facilitating the Merit-Based Proposal Review and Evaluation Process

Merit review is a critical component of the National Science Foundation's decision-making process for funding research and education projects. Through use of rigorous, competitive merit review, NSF maintains high standards of excellence and accountability. NSF selects the reviewers from among the national and international pool of experts in each field.

Reviewer Management capabilities will enhance the Foundation's capability to support the merit review process by providing better information and tools that support each stage of the Reviewer Management lifecycle. Currently, there is limited capability to support the identification, selection, assignment, and tracking of individuals who serve as reviewers. FY 2009 funding will provide tools that enable NSF Program Officers to quickly find reviewers based on field of expertise and other important criteria, and easily identify potential conflicts of interest. Planned work includes improving reviewer capability for collaborative proposals and large interdisciplinary and cross-cutting panels; improving panel setup and coordination; streamlining travel, scheduling, badging, and financial reimbursement; and providing a post-review collaborative environment. Reviewer Management tools will help NSF establish an increasingly diverse pool of highly qualified reviewers for future selection.

Supporting Proposal Processing and Award Management

NSF processes approximately 40,000 proposals annually. Every proposal is acted on – either returned without review, withdrawn, declined or awarded. One of NSF's performance goals is for 70 percent of proposals, to be able to inform applicants whether their proposals have been declined or recommended for funding within six months of deadline or target date or receipt date, whichever is later. In support of this goal, investments such as the electronic Jacket (eJacket) and Award systems provide Foundation staff an electronic method for processing proposals after submission.

The eJacket system serves as a one-stop electronic web portal for NSF staff to perform essential business functions related to proposal and award processing. Each electronic jacket serves as a container for all documents related to a specific proposal or award. eJacket provides a common place for program staff to assign proposals to program officers, record recommendations for declinations, process electronic correspondence, and facilitate committee of visitors reviews. In FY 2007 alone, eJacket successfully supported 206,000 electronic reviews and 340,000 items of electronic correspondence.

NSF staff use the award system to process all award actions electronically. The award system has been in operation since FY 2000 and is in need of a major modernization. All processes related to approving an award action are performed through this system, such as logging an award action, composing an award letter, reviewing the action, and approving the action. Upon approval, the Award system also sends an electronic notification to the grantee.

NSF makes approximately 10,000 new awards annually and is committed to results-oriented program management and stewardship. FY 2009 funding will improve capabilities for NSF program staff to perform critical actions during the award phase – such as expanding eJacket to support proposals which are recommended for award and upgrading the current legacy Award system to a web-based environment. NSF is also investing in collaborative and knowledge management tools to facilitate program decision making. These investments set the stage for NSF to move to improved program portfolio management, oversight, and post-award monitoring of awards; the result of which will be more efficient NSF processing of awards and increased integrity of the award process.

NSF requires financial and technical project reports for all assistance awards. The Foundation's final reporting requirements and close-out procedures seek to ensure that funds have been properly used without imposing complex or overly burdensome requirements on award recipients. The project report tracking and notification system assists awardees with identifying reporting requirements, reporting periods (due and overdue) and the status of reports. Due and overdue e-notices are sent automatically to the Sponsored Projects Offices to help ensure timely submission of project reports. FY 2009 plans include expanding Research.gov to offer enhanced reporting capabilities using the new government-wide research and related data set. This will provide online services for research institutions to complete and submit federal financial reports and research performance progress project reports. Funding is also being requested to evaluate modern financial management system capabilities.

Enabling Public Dissemination of Research Information and Results

NSF uses a variety of communication channels to disseminate information to scientists, engineers, university administrators, educators, businesses, vendors, the media, policy makers, and the interested general public. NSF's primary audience is the research and education community. Potential applicants for NSF support use NSF websites for information on sources of funding, procedures for application, and how to manage an award. NSF provides the public with full access to research results that come from NSF funding through two mission critical initiatives: Public Access to Research Results and Research.gov Research Spending and Results.

The Public Access to Research Results initiative directly links information on NSF-funded science and research awards to citations of journal articles that have been published as a result of the award. These results are provided in the form of citations entered by Principal Investigators into FastLane and made available to members of the public via the Award Search feature of the NSF web site and the Research.gov web portal. To date, over 50,000 citations have been added using the new search utility in FastLane. Planned enhancements will provide additional functionality and benefit to NSF and its constituents. The implementation of Public Access to Research Results helps NSF to better demonstrate the benefits of funded research.

In addition to publication citations, the public can view detailed award information and award abstracts through Research.gov Research Spending and Results. Research Spending and Results is a service to fully disclose research grant award data in compliance with the Federal Funding Accountability and Transparency Act of 2006 and the e-Government Act of 2002. The Act requires Federal agencies to make information accessible and searchable by the public for free, including the following for each Federal award: legal name of the entity receiving the award; award date, description, and identifier; total funds obligated to date; information on the award including transaction type, funding agency, program source, etc; the location of the entity receiving the award including Congressional District; and a unique identifier of the entity receiving the award. In addition to information required by the Transparency Act, Research Spending and Results includes the award abstract, publication citations, Project Director/Principal Investigator, and award start and end date for each Federal award. This advanced search capability provides transparency about how research grant dollars are being spent and what results are being achieved.

Enhancing Management of Program Operations

To ensure critical mission-related processes are conducted efficiently, effectively, and with integrity; NSF seeks to design, recruit, hire, train, and retain a diverse, capable, and motivated science and engineering workforce. NSF recruits heavily from the science and engineering research and education community, particularly to fill rotating positions as science program managers. These temporary assignments, normally for 1-2 years, bring valuable expertise and new ideas to NSF. When NSF "rotators" return to their home institutions, they often become valued "experts" in NSF funding process and the overall Federal R&D enterprise.

NSF organizations now conduct annual workforce and staff planning efforts to align their workforce plan for the near-term future with NSF strategic objectives and to identify strategic program positions to be filled in the upcoming year. NSF executives, program managers, and administrative staff all conduct extensive outreach to the community to identify candidates for NSF program positions. Once candidates for program positions are selected and come on board, NSF provides extensive orientation to NSF policies, practices, and culture as well as job-specific training in program-related processes and systems. These activities have seen significant improvement in the last few years, but there is much to be done.

In subsequent years, NSF is committed to developing comprehensive information technology systems, with emphasis on personnel performing mission-support functions. NSF will also design and offer improved development opportunities targeted toward leadership development, enhanced new program officer orientation, and more effective instruction in NSF's core processes including merit review.

NSF's business cases can be found at: www.nsf.gov/policies/foia.jsp.

E-Government Initiatives

NSF is providing funding contributions in FY 2008 and FY 2009 to these E-Government Initiatives:

NSF FY 2008 Funding for E-Government Initiatives

Initiative	FY 2008 Agency Contributions	FY 2008 Agency Svc. Fees	NSF Total	Appropriations Account AOAM	R&RA	EHR
Grants.gov	$536,187	-	**$536,187**	-	$466,483	$69,704
Grants Management LoB	174,360	-	**174,360**	-	151,693	22,667
E-Authentication	-	97,100	**97,100**	97,100	-	-
E-Travel	-	164,439	**164,439**	164,439	-	-
Geospatial LoB	15,450	-	**15,450**	-	13,441	2,009
E-Training	-	370,000	**370,000**	370,000	-	-
E-Rulemaking	135,000	-	**135,000**	-	117,450	17,550
Business Gateway	22,000	-	**22,000**	-	19,140	2,860
Recruitment One-Stop (USA Jobs)	-	4,684	**4,684**	4,684	-	-
E-HRI[1]	-	447,600	**447,600**	447,600	-	-
Integrated Acquisition Environment	12,961	-	**12,961**	-	11,276	1,685
Human Resources Management LoB	65,217	-	**65,217**	-	56,739	8,478
Financial Management LoB	44,444	-	**44,444**	-	38,666	5,778
Budget Formulation/Execution LoB	85,000	-	**85,000**	-	73,950	11,050
IT Infrastructure LoB	20,000	-	**20,000**	-	17,400	2,600
IAE- Loans and Grants	89,973	-	**89,973**	-	78,277	11,696
E-Payroll (incl. Shared Services)	-	304,704	**304,704**	304,704	-	-
Total	$1,200,592	$1,388,527	**$2,589,119**	$1,388,527	$1,044,515	$156,077

Totals may not add due to rounding.

[1]E-HRI: Amount covers tools, service fees and implemention costs for eOPF. If implementation of eOPF were not to occur

NSF FY 2009 Funding for E-Government Initiatives

Initiative	FY 2009 Agency Contributions	FY 2009 Agency Svc. Fees	NSF Total	Appropriations Account AOAM	R&RA	EHR
Grants.gov	$517,763		**$517,763**		$450,454	$67,309
Grants Management LoB	174,360		**174,360**		151,693	22,667
E-Authentication		194,900	**194,900**	194,900		
E-Travel		150,038	**150,038**	150,038		
Geospatial LoB	15,000		**15,000**		13,050	1,950
E-Training		370,000	**370,000**	370,000		
E-Rulemaking		5,100	**5,100**	5,100		
Business Gateway	49,388		**49,388**		42,968	6,420
Recruitment One-Stop (USA Jobs)		4,871	**4,871**	4,871		
E-HRI		48,724	**48,724**	48,724		
Integrated Acquisition Environment		18,866	**18,866**	18,866		
Human Resources Management LoB	65,217		**65,217**		56,739	8,478
Financial Management LoB	44,444		**44,444**		38,666	5,778
Budget Formulation/Execution LoB	95,000		**95,000**		82,650	12,350
IT Infrastructure LoB			**0**		0	0
IAE- Loans and Grants	89,973		**89,973**		78,277	11,696
E-Payroll (incl. Shared Services)		304,704	**304,704**	304,704		
Total	$1,051,145	$1,097,203	**$2,148,348**	$1,097,203	$914,496	$136,649

Totals may not add due to rounding.

Benefits realized through the use of these initiatives are as follows:

- *Grants.gov*

  The Grants.gov Initiative provides grant applicants with a single source to search and apply for funding opportunities from all Federal grant-making agencies using common forms, processes, and systems. With NSF's full implementation of Grants.gov, the research community can now find and apply for NSF funding opportunities on Grants.gov as well as through NSF's FastLane web site. In FY 2007, NSF published all of its funding opportunities on Grants.gov and published associated application packages for nearly all of those opportunities. In FY 2007 NSF received over 1,600 electronic applications through Grants.gov, more than double the amount from FY 2006.

- *Grants Management Line of Business (GM LoB)*

  NSF manages a portfolio of awards totaling approximately $5 billion. The key advantage of our leading a GM LoB consortium has been the opportunity for us to leverage lessons learned from our experience with the development and implementation of FastLane, to the government-wide arena. As a consortium lead, NSF has developed Research.gov, a web portal that will provide a menu of modern grants management services and the latest news and information for the research community. Through this exciting new initiative, NSF's leadership as co-Managing Partner of GM LoB, and specifically our role as a consortium lead, is providing benefits to other federal agencies sponsoring research; program officers; and, research institutions doing business with the Federal Government.

Automated business processes available through consortium service providers will decrease agency reliance on manual and paper-based processing. Consortium lead agencies will spread operations and maintenance (O&M) costs, and development, modernization, and enhancement (DME) costs across agencies, decreasing the burden that any one agency must bear.

Over time, the GM LoB will lead to common data and reporting standards, a reduction in the number of systems of records for grants data across the government, and increased service to the applicant and awardee community. In particular, the standardization of data and reporting standardization will improve the government's ability to provide agency- and government-wide reports on grant activities and results.

In our role as consortium lead, NSF will maintain its ability to comply with the Federal Financial Assistance Management Improvement Act of 1999 and will meet the requirements of the Federal Funding Accountability and Transparency Act of 2006.

Constituents will benefit from the standardization and streamlining of government-wide grants business processes. GM LoB will minimize complex and varying agency-specific requirements, like annual and final reporting. Constituents will save time and money with fewer unique agency systems and processes to learn; the new federal grant systems will be easier to learn so reliance on call center technical support will be reduced.

- *E-Authentication*

This initiative provides E-Authentication expertise, guidance, and documentation, including project planning and reporting templates, to enable NSF to implement E-Authentication for agency applications. The E-Authentication Federation allows NSF to use identity credentials issued and managed by organizations within and outside the Federal Government, thereby relieving NSF of the responsibility for providing its own identity management solutions.

- *Geospatial One Stop/Line of Business*

Although NSF is not currently a provider of a geospatial data, it does consider proposals for support of fundamental research that utilize or enhance the value of geospatial information. NSF recognizes the importance of the LoB in establishing a more collaborative and performance-oriented culture within the Federal geospatial arena that should optimize investments in data and technology and yield many long-term benefits to the nation.

- *E-Rulemaking*

NSF's support of fundamental science and engineering research requires the Foundation to maintain constant contact with the research community. Regulations.gov, the E-Rulemaking online portal, provides the research community (as well as members of the public) with a one-stop web-based, central location to track regulations proposed by NSF and to provide comment when applicable. The Federal Docket Management System (FDMS) allows NSF to manage its regulatory information in a system developed through other agency best-practices and collaboration.

- *Business Gateway*

By creating a single portal for business information, such as regulatory compliance information, Business Gateway directly benefits NSF's "customers" (e.g., research firms, universities, etc.), many of whom are subject to complex regulatory requirements across multiple agencies. NSF's constituents could potentially receive significant benefits from Business Gateway including time and cost savings, assistance in compliance with the Small Business Paperwork Relief Act (SBPRA), and reduction in burden hours. Through increased outreach, more constituents will be able to realize these benefits.

NSF will also benefit in specific ways from participation in the Business Gateway initiative. The web search technology on Business.gov will provide NSF with user statistics about information most sought by customers, which will enable the agency to improve the management of web content related to business compliance. By making forms available on Forms.gov, NSF saves agency time in forms management, and is expected to produce significant savings in paper and postage.

- *Integrated Acquisition Environment (IAE)*

  The tools and services provided by IAE allow NSF to make informed and efficient purchasing decisions and replace manual processes. Without the IAE systems, NSF would need to build and maintain separate systems to record vendor and contract information, and to post procurement opportunities. Agency purchasing officials would not have access to other agencies' information on vendor performance, and would have to rely on paper-based and labor-intensive work efforts.

- *Human Resources Management Line of Business (HR LoB)*

  The HR LoB services and initiatives provide NSF with best-in-class HR services and systems. Through NSF's adoption of an approved service provider, the agency can achieve the benefits of advanced HR solutions without the costs of developing and maintaining its own HR systems. NSF's involvement in the HR LoB allows NSF to help shape the government-wide solution and benefit from the best practices and lessons learned as developed by the HR LoB task force and other agencies.

- *Financial Management Line of Business*

  The FM LoB uses a Shared Service Provider (SSP) to promote standard business processes and common system configurations. Reliance on SSPs helps keep capital investment and risk to a minimum. NSF's involvement with FM LoB will enable it to benefit from future system modernization efforts. In the short-term, key tools such as a Request for Proposal (RFP) framework and Service Level Agreement (SLA) guides will be provided to NSF.

- *Budget Formulation and Execution Line of Business*

  The BFE LoB plans to make at least one government off-the-shelf (GOTS) budget formulation system available for purchase or use via a fee-for-service arrangement. NSF will be able to utilize the planned BFE LoB guidance for budget system procurement. The guide will include a listing of agencies and their current budgeting systems, information on various budgeting systems that are currently available in the market place (both GOTS and COTS – commercial off-the-shelf), and a decision matrix that agencies can use in assessing budgeting systems. Additionally, agencies will have the ability to share lessons learned for budget formulation, execution, planning, performance measurement, and financial management information and activities across the government. The BFE LoB will provide all agencies with more information about collaborative tools and technologies to facilitate communications in the Federal budget environment.

- *IT Infrastructure Line of Business*

  The IT Infrastructure LOB will provide NSF with best practice data and industry-wide performance metrics related to investments in IT infrastructure. It will allow NSF to validate and/or improve existing system performance.

AGENCY OPERATIONS AND AWARD MANAGEMENT $305,060,000

The FY 2009 Budget Request for Agency Operations and Award Management (AOAM) is $305.06 million, an increase of $23.27 million, or 8.3 percent, over the FY 2008 Estimate of $281.79 million. Adequate funding for AOAM, particularly for staffing and information technology, is critical to the efficient operations of the agency.

Summary of Agency Operations and Award Management by Function

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Human Capital					
Personnel Compensation & Benefits	$160.93	$178.49	$191.58	$13.09	7.3%
Management of Human Capital	6.72	7.13	7.63	0.50	7.0%
Operating Expenses	9.24	10.06	12.27	2.21	22.0%
Travel	5.52	8.95	10.90	1.95	21.8%
Subtotal, Human Capital	182.41	204.63	222.38	17.75	8.7%
Technology and Tools					
Information Technology	34.82	42.18	45.08	2.90	6.9%
Space Rental	21.60	23.50	25.00	1.50	6.4%
Other Infrastructure	9.65	11.48	12.60	1.12	9.8%
Subtotal, Technology and Tools	66.07	77.16	82.68	5.52	7.2%
Total, AOAM	$248.48	$281.79	$305.06	$23.27	8.3%

Totals may not add due to rounding.

AOAM NSF Workforce

(Full-Time Equivalent (FTE) and Other Staff)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
NSF AOAM -- Regular	1,196	1,270	1,295	25	2.0%
NSF AOAM -- Student	32	40	40	-	-
Subtotal, FTE Allocation	1,228	1,310	1,335	25	1.9%
Detailees to NSF	3	6	6	-	-
Total, Workforce	1,231	1,316	1,341	25	1.9%

Appropriation Language

For agency operations and award management necessary in carrying out the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-1875); services authorized by 5 U.S.C. 3109; hire of passenger motor vehicles; not to exceed $9,000 for official reception and representation expenses; uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; rental of conference rooms in the District of Columbia; and reimbursement of the ~~General Services Administration~~*Department of Homeland Security* for security guard services; ~~$281,790,000.~~*$305,060,000: Provided*, That contracts may be entered into under this heading in fiscal year ~~2008~~*2009* for maintenance and operation of facilities, and for other services, to be provided during the next fiscal year.

Agency Operations and Award Management
FY 2009 Summary Statement
(Dollars in Millions)

	Enacted/ Request	P.L. 110-161 Rescission	Transfers	Expired	Total Resources	Obligations Incurred/Est.
FY 2007 Appropriation	$248.25	-	$0.25	-$0.01	$248.49	$248.49
FY 2008 Estimate	281.79	-	-		281.79	281.79
FY 2009 Request	305.06	-	-		305.06	305.06
$ Change from FY 2008						$23.27
% Change from FY 2008						8.3%

Summary of Major Changes ***(Dollars in Millions)***

FY 2008 Estimate, AOAM……….……….……..……………………………………..........…$281.79

Human Capital +$17.75

Funding for Human Capital increases by $17.75 million to a total of $222.38 million, a 8.7 percent increase over the FY 2008 Estimate. The major components of this increased investment are:

- $191.58 million for Personnel Compensation and Benefits (PC&B), an increase of $13.09 million ($5.91 million for salary of additional FTE), which supports an increase in the usage of full-time equivalents to an FTE allocation of 1,295 regular employees. The increase also reflects comparability and locality pay ($4.17 million) and costs related to employee benefits.
- $7.63 million for Management of Human Capital, which represents an increase of $500,000 over the FY 2008 Estimate. Funds will be used to address inflationary pressures on current services, pay increased fees to shared service providers, and provide sufficient funding to meet personnel security requirements.
- $12.27 million, an increase of $2.21 million in general operating expenses including costs of supplies, equipment, and other operating expenses necessary for the management of NSF's research and education activities. This increase will also support assistance in award oversight and monitoring, A-123 review, and the costs associated with additional staff.
- $10.90 million for travel, an increase of $1.95 million over the FY 2008 Estimate for award oversight activities, science and engineering meetings, and strategic training. The increase in the travel request reflects the Foundation's focus on more oversight review.

Technology and Tools +$5.52

Funding for Technology and Tools is $82.68 million, which represents an increase of $5.52 million, or 7.2 percent, over the FY 2008 Estimate. Major components of this investment are:

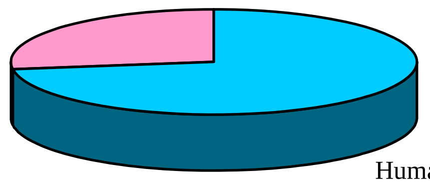
- $45.08 million for Information Technology (IT), an increase of $2.90 million over the FY 2008 Estimate. This funding level will permit the Foundation to implement key infrastructure maintenance and operations initiatives, including deploying the next generation network, hosting business applications on a modern technology platform, modernizing email redundancy and archiving capabilities, and providing additional remote access capabilities to support and increase the productivity of teleworkers and traveling staff.
- $25.0 million for Space Rental, an increase of $1.50 million over the FY 2008 Estimate. The increase is required to offset rising GSA rental costs and real estate taxes, increased utility costs, plus funding of additional leased office space that will be needed to accommodate additional staff in FY 2009.
- $12.60 million for Other Infrastructure, an increase of $1.12 million over the FY 2008 Estimate. This increase will be used for programs such as the installation of a new physical and security access system for the agency's buildings, upgrades to the agency's emergency and continuity of operations programs, and to providing mission support for the agency's travel management program.

Subtotal, Changes +$23.27

FY 2009 Request, AOAM ……..…………………………….……….…………………........$305.06

AGENCY OPERATIONS AND AWARD MANAGEMENT – FY 2009 REQUEST BY MAJOR FUNCTION

FY 2009 AOAM Request of $305.06 Million



NSF is committed to supporting excellence in science and engineering research and education. In order for NSF to excel, the Foundation must have strong infrastructure and management. To acknowledge this, the NSF Strategic Plan includes Stewardship as a strategic goal, on a par with NSF's established science and engineering goals of Discovery, Learning, and Research Infrastructure. The Strategic Plan defines Stewardship as: "support excellence in science and engineering research and education through a capable and responsive organization."

The NSF plan includes a number of long-term priorities for the Stewardship goal. These emphasize improving transparency, consistency, and uniformity of the merit review process; continued emphasis on award oversight and management, particularly for large facilities; and implementing a range of activities to maintain and strengthen relationships with the agency's key stakeholders in the research and education community.

HUMAN CAPITAL ($228.38 million)

The FY 2009 request for Human Capital totals $228.38 million, an increase of $17.75 million, or 8.7 percent, over the FY 2008 Estimate of $204.63 million. These investments consist of four major components: Personnel Compensation and Benefits, Management of Human Capital, Operating Expenses, and Travel.

Human Capital Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Personnel Compensation and Benefits	$160.93	$178.49	$191.58	$13.09	7.3%
Management of Human Capital	6.72	7.13	7.63	0.50	7.0%
Operating Expenses	9.24	10.06	12.27	2.21	22.0%
Travel	5.52	8.95	10.90	1.95	21.8%
Total, Human Capital	$182.41	$204.63	$222.38	$17.75	8.7%

Totals may not add due to rounding.

Personnel Compensation and Benefits ($191.58 million)

Personnel Compensation & Benefits
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount[3]	Percent
Regular FTE Allocation	1,248	1,270	1,295	25	2.0%
Regular FTE Usage (actual/projected)	*1,196*	*1,240*	*1,280*	*40*	*3.2%*
Regular Salary					
Base Salary	$122.75	$134.79	$136.01	$1.22	0.9%
Salary Cost of Additional FTE	-	5.01	5.91	-	-
COLA & Locality Pay[1]	-	5.84	4.17	-	-
Subtotal, Regular FTE Salary	$122.75	$134.79	$146.09	$11.30	8.4%
Student FTEs	*32*	*40*	*40*	-	-
Student Salary	$0.93	$1.14	$1.23	$0.09	7.9%
Total, FTEs	*1,228*	*1,280*	*1,320*	*40*	*3.1%*
Subtotal, FTE Pay	$123.68	$135.93	$147.32	$11.39	8.4%
Benefits and Other Compensation[2]	37.25	42.56	44.26	1.70	4.0%
Total, PC&B	$160.93	$178.49	$191.58	$13.09	7.3%

[1]The pay increase includes the annualization of the FY 2008 pay raise, nine months of the projected FY 2009 pay raise, as well as anticipated within grades and promotion increases. FY 2008 has two additional work days.

[2]This category includes employee benefits, detailees to NSF, terminal leave, awards, and other benefits.

[3]The increase in the FY 2009 base salary reflects the full annual cost of employees hired throughout FY 2008.

The FY 2009 request for Personnel Compensation and Benefits is $191.58 million, an increase of $13.09 million, which fully funds 1,280 FTE (1,295 employees by the end of year) and includes comparability and locality pay and costs related to employee benefits.

The additional 40 FTE included in the Request reflects the on-going effort to hire a sufficient number of staff to meet the growing and increasingly complex workload being experienced throughout the Foundation. The additional staff will manage a growing proposal workload and award oversight and management. The FTE increase will also help to more efficiently manage incoming proposals and the merit review process.

Management of Human Capital ($7.63 million)

The FY 2009 Management of Human Capital request is $7.63 million, an increase of $500,000, or 7 percent, over the FY 2008 Estimate of $7.13 million. This increase in funding is critical to address inflationary pressures on current services, pay increased fees to shared service providers, and have sufficient funding to meet personnel security requirements.

Operationally, the funding will be used for recruitment and retention activities targeting scientists, engineers, and educators who reflect the diversity of the communities served. Emphasis will continue to be placed on policies designed to attract and retain high quality staff.

Resources will also be used to address succession planning, leadership, and employee development strategies to support supervisory and managerial education programs, with special emphasis on the rotational nature of many of NSF's managerial personnel.

FY 2009 funds will continue to support workforce and staffing planning, health unit and employee assistance services, provision of personnel processing and payroll services, and operational and strategic support to assist in the accomplishment of objectives in NSF's Strategic Plan.

In addition, NSF will analyze program officer developmental needs and begin development of a comprehensive program management and merit review curriculum focused on the key principles that will allow permanent and rotating staff to understand and fulfill the strategic objectives of the agency.

Operating Expenses ($12.27 million)

Operating Expenses increase by $2.21 million, or 22.0 percent, to $12.27 million in FY 2009. These include direct costs of supplies, equipment, and other operating expenses necessary for the management of NSF's research and education activities. Operating Expenses also includes services for technical assistance in award oversight and monitoring, which addresses findings from recent financial statement audits.

Travel ($10.9 million)

Travel increases by $1.95 million, or 21.8 percent, to $10.90 million in FY 2009. These travel resources will enable NSF to increase oversight of existing awards (as recommended by the agency's Inspector General), intensify management and oversight activities, enable staff to participate in national and international science and engineering conferences and workshops, and provide access to strategic training opportunities. The majority of the increase will support travel for program management staff for oversight and training objectives.

TECHNOLOGY AND TOOLS ($82.68 million)

The FY 2009 request for Technology and Tools is $82.68 million, an increase of $5.52 million, or 7.2 percent, over the FY 2008 Estimate of $77.16 million. These investments consist of three major components: Information Technology, Space Rental, and Other Infrastructure.

Technology and Tools Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Information Technology	$34.82	$42.18	$45.08	$2.90	6.9%
Space Rental	21.60	23.50	25.00	1.50	6.4%
Other Infrastructure	9.65	11.48	12.60	1.12	9.8%
Total, Technology and Tools	$66.07	$77.16	$82.68	$5.52	7.2%

Totals may not add due to rounding.

Agency Operations Information Technology

The FY 2009 Information Technology request is $45.08 million, an increase of $2.90 million over the FY 2008 Estimate. This level will enable the Foundation to deliver mission support administrative services and support a high quality, highly reliable, and secure infrastructure that is responsive to customer needs.

Summary of Agency Operations Information Technology (IT)

(Dollars in Millions)

				Change over FY 2008 Estimate	
Agency Operations IT	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Amount	Percent
Applications Services and Support	$16.27	$19.88	$19.03	-$0.85	-4.3%
Infrastructure Services and Support	16.10	18.33	22.94	4.61	25.2%
Security and Privacy Services and Support	2.45	3.97	3.11	-0.86	-21.7%
Total, Information Technology	$34.82	$42.18	$45.08	$2.90	6.9%

Totals may not add due to rounding.

- ***Applications Services and Support***

  In FY 2009, funding for these initiatives will decrease from $19.88 million to $19.03 million. Investments in this category will be used to secure, support and modernize administrative applications such as human resources, property tracking, and records management. Applications that directly support science and engineering research and education activities, including Research.gov and Reviewer Management, will be funded by program funds as described within the Program Related Information Technology justification.

  The FY 2009 Request will enable NSF to replace the legacy time and attendance system, implement an electronic Official Personnel Folder, and invest in additional components of a comprehensive Human Resource Information System, including Workforce/Succession Planning, Performance Management, and Benefits/Retirement Management. A Workforce/Succession Planning System at NSF will include components for employee tracking and management at the NSF and organizational levels, organizational and NSF-wide staffing planning, organizational and NSF-wide succession planning and management for key positions, and individual and organizational competency and skill gap assessment.

  In FY 2009, funding will also be used to maintain NSF's existing financial and accounting system and travel functions. The Financial Accounting System is used to manage funds and provides a full spectrum of financial transaction functionality and interfaces with NSF systems, including the eTravel and Learning Management Systems. NSF staff use the eTravel system to plan travel, approve travel plans, prepare expense vouchers, or manage travel cards.

- ***IT Infrastructure Maintenance and Operations***

  In FY 2009, support for IT Infrastructure Maintenance and Operations will increase from $18.33 million to $22.94 million. Funding will allow implementation of key initiatives such as: deploying a modern network platform to host business applications, modernizing email redundancy and archiving capabilities, and providing additional remote access capabilities to support and increase the productivity of teleworkers and traveling staff. This funding will provide basic maintenance and operations levels for ongoing operations and support new efforts essential for system modernization, such as directory services and tools to manage configuration, quality assurance, and software testing. The funding will also enable planned technical refresh projects, deploying additional system redundancy to increase operational stability, and initiatives to expand and automate support to accommodate an increasingly distributed 24x7 user community. Funding will expand help desk services that support new applications and improvements to desktop configuration management. Additionally, NSF is transitioning to funding IT Infrastructure services for applications that directly support science and engineering, research and education activities (including Research.gov and Reviewer Management) out of program accounts as described within the Program Related Information Technology justification.

FY 2009 funding will support enterprise architecture efforts that define current, target, and transitional architecture to frame future NSF IT investments. This investment will be used to continue NSF's earned value management capabilities and support more integrated investment planning to improve the management of major IT projects.

- ***IT Security and Privacy***

  In FY 2009, Agency Operations IT funding for IT Security and Privacy will decrease from $3.97 million to $3.11 million. The decrease in this category represents a shift in funding sources; i.e., activities to secure systems will be funded by program funds as described within the Program Related Information Technology justification. This shift reflects the high priority the Foundation places on IT security and the continued protection of sensitive information as required by privacy policies. These investments allow NSF to acquire and maintain automated configuration management tools that manage patches and provide proactive protection from viruses, spyware, etc. While investments in FY 2008 will be used to eliminate use of Social Security Numbers (SSNs) within NSF applications when they are not required for business purposes, FY 2009 investments are needed to enhance the protection of applications and systems where personally identifiable information (PII) such as SSNs must be used for business purposes, per federal standards and policies. Funds will also be used for analysis and planning to support transition to a government-wide service provider for FISMA reporting.

  While NSF's security program is strong, continued investment in robust solutions is needed to meet evolving and more serious threats. Critical investments are needed to support specific areas such as: network security, application security, security control testing and tools, automated vulnerability assessment tools, and remediation and intrusion detection services. NSF will fully fund security activities including risk assessments, security control testing, contingency planning, and implementing and evaluating a business continuity capability. Without this level of investment, NSF will not be able to deploy tools and practices to address emergent threats, or provide layered security capabilities needed to assure a sound security posture. Funding will also allow NSF to implement functionality to address new mandates for improved controls to assure protection of privacy and sensitive information.

Summary of Space Rental and Other Infrastructure by Function
(Dollars in Millions)

Space Rental & Other Infrastructure	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Space Rental	$21.60	$23.50	$25.00	$1.50	6.4%
Other Infrastructure	9.65	11.48	12.60	1.12	9.8%
- Administrative Contracts	*4.05*	*5.81*	*6.00*	*0.19*	*3.3%*
- Government Goods and Services	*3.29*	*3.30*	*3.60*	*0.30*	*9.1%*
- Administrative Services Equipment & Supplies	*2.31*	*2.37*	*3.00*	*0.63*	*26.6%*
Total, Space Rental & Other Infrastructure	$31.25	$34.98	$37.60	$2.62	7.5%

Space Rental

The FY 2009 request for Space Rental is $25.0 million, an increase of $1.50 million, or 6.4 percent, over the FY 2008 Estimate. These resources will offset escalating GSA rental costs, increased real estate taxes, and rising utility costs, plus additional leased office space needed to accommodate additional staff for FY 2009. The additional office space comprises roughly $600,000 of the increase and includes rent for new space as well as annualizing costs for space acquired in the previous year.

Other Infrastructure

In FY 2009, support for Other Infrastructure is $12.60 million, an increase of $1.12 million over the FY 2008 Estimate.

Other Infrastructure funding supports the following major sets of activities:

Administrative Contracts will support costs for programs such as the installation of a new physical and security access system for the agency's buildings, upgrades to the agency's emergency and continuity of operations programs, and providing mission support for the agency's travel management program.

Government Goods and Services will support expenditures for security guards and building improvements such as space updating and renovation and office space realignment and programs to support new energy efficiency programs.

Administrative Services Equipment and Supplies and Periodicals costs will increase significantly to provide much needed upgrades to the agency's physical infrastructure, and to support scheduled equipment replacement programs.

Agency Operations and Award Management by Object Class

The following table shows the planned distribution of general operating expenses (GOE) by object class and salaries and benefits. A brief explanation of each general operating expenses category follows.

General Operating Expenses by Object Class
and Salaries and Benefits
(Dollars in Thousands)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Travel and Transportation of Persons	$5,518	$8,950	$10,900	$1,950	21.8%
Transportation of Things	177	230	230	-	-
Rental Payments to GSA	21,778	23,500	25,000	1,500	6.4%
Communications, Utilities and Misc. Charges	4,942	1,450	1,589	139	9.6%
Printing and Reproduction	119	100	100	-	-
Advisory and Assistance Services	40,387	12,782	13,802	1,020	8.0%
Other Services	9,023	8,900	10,295	1,395	15.7%
Purchases of Goods & Srvcs from Gov't. Accts	507	3,300	3,600	300	9.1%
Medical Care	19	575	600	25	4.3%
Operations and Maintenance of Equipment	825	28,490	34,403	5,913	20.8%
Supplies and Materials	2,156	2,750	3,100	350	12.7%
Equipment	2,102	12,273	9,861	-2,412	-19.7%
Subtotal, GOE	87,553	103,300	113,480	10,180	9.9%
Salaries and Benefits (PC&B)	160,934	178,490	191,580	13,090	7.3%
Total, AOAM	$248,487	$281,790	$305,060	$23,270	8.3%

Totals may not add due to rounding.

Note: In FY 2008 and 2009 IT contracts in object class Advisory and Assistance Services are reclassified as Equipment and O&M of Equipmen

Description of categories:

- **Travel and Transportation of Persons** increases by $1.95 million over the FY 2008 Estimate. These resources fund travel required for planning, outreach, and increased oversight of existing awards as recommended by the agency's Inspector General.

- **Transportation of Things** consists of household moves associated with bringing new staff to NSF. Resources for this activity remain flat with the FY 2008 Estimate.

- **Rental Payments to GSA** includes the rent charged by GSA for NSF's facility in Arlington, Virginia, and additional floors in an adjacent building. The increase of $1.50 million in FY 2009 is required to offset escalating GSA rental costs, increased real estate taxes, and rising utility costs, plus funding of additional leased office space that will be needed to accommodate additional staff for FY 2009.

- **Communications, Utilities, and Miscellaneous Charges** includes all costs for telephone lines and services, both local and long distance, and postage. Funds increase by $139,000 from the FY 2008 Estimate to cover inflationary increases.

- **Printing and Reproduction** includes contract costs of composition and printing of NSF's publications, announcements, and forms, as well as printing of stationery and specialty items. These costs remain essentially constant with the FY 2008 Estimate.

- **Advisory and Assistance Services** includes development, learning, and career enhancement opportunities offered through the NSF Academy, contracts for human capital operational activities, work life initiatives, outreach, and related services. Included in the FY 2009 increase of $1.02 million, is an increase of $660,000 to address inflationary pressures on current services, to pay increased fees to shared service providers, and to provide sufficient funding to meet personnel security requirements.

- **Other Services** include warehousing and supply services, mail handling, proposal processing, equipment repair and maintenance, building-related costs, furniture repair, contract support for conference room services, security investigations, and miscellaneous administrative contracts. The FY 2009 Request increases by $1.40 million over the FY 2008 Estimate to support increases in costs for programs such as enhanced physical and security access systems, and e-travel service contracts to support the government-wide travel initiative.

- **Purchases of Goods and Services from Government Accounts** includes reimbursable services purchased from GSA. These costs include security guard services, some electrical upgrades, and modest renovation services. Funds for this activity increased by $300,000 over the FY 2008 Estimate to cover services associated with new leased space.

- **Medical Care** includes costs associated with the health services contract, providing limited on-site medical services to the agency's staff. This also includes performing physical examinations for the NSF staff on assignment at the South Pole. Funds for this activity increase by $25,000 over the FY 2008 Estimate to cover inflationary increases.

- **Operations and Maintenance of Equipment** includes management and operation of the central computer facility 24 hours/day, 365 days/year; operation of the customer service center and FastLane help desk; maintenance of database server hardware and related peripherals; software licensing fees; data communications infrastructure and network systems support; electronic mail support; and remote access (e.g., internet and World Wide Web). Costs increase by $5.91 million in FY 2009 to implement key infrastructure maintenance and operations initiatives such as deploying a modernized network, hosting business applications on a modern technology platform, and modernizing email redundancy and archiving capabilities.

- **Supplies and Materials** include office supplies, library supplies, paper and supplies for the NSF central computer facility, and miscellaneous supplies.

- **Equipment** costs include new and replacement computing equipment, desktop computers, data communications equipment, video-teleconferencing equipment, office furniture, file cabinets, and support equipment such as audio-visual equipment. These costs decrease by $2.41 million in FY 2009, driven by the Foundation's decision to move towards off-site hosting as well as the reclassification of mission-related equipment to Program Related Information Technology.

NATIONAL SCIENCE BOARD $4,030,000

Since FY 2003, the activities of the National Science Board (NSB) have been funded through a separate appropriation. This was initially established in the National Science Foundation (NSF) Authorization Act of 2002, and the recently enacted America COMPETES Act of 2007 similarly included a separate appropriation for the NSB. Accordingly, this FY 2009 Budget Request identifies the resources needed to support the Board, including amounts for personnel compensation and benefits, authorized travel, employment of external experts and consultants, and other appropriate expenses. The FY 2009 Request is $4.03 million, an increase of $61,000, or 1.5 percent, over the FY 2008 Estimate of $3.97 million. The FY 2009 Budget Request will continue to enable the Board to fulfill its policy-making and oversight responsibilities for NSF and provide independent advice to the President and the Congress on significant national policy issues in science and engineering (S&E) research and education.

National Science Board Funding

(Dollars in Millions)

				Change over FY 2008 Estimate	
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Amount	Percent
Personnel Compensation and Benefits	$1.87	$1.86	$1.92	$0.06	3.2%
Other Operating Expenses	1.78	2.11	2.11	-	-
Total	$3.65	$3.97	$4.03	$0.06	1.5%
Full-Time Equivalent Employment	15	14	14	-	-

Totals may not add due to rounding.

Appropriation Language

For necessary expenses (including payment of salaries, authorized travel, hire of passenger motor vehicles, the rental of conference rooms in the District of Columbia, and the employment of experts and consultants under section 3109 of title 5, United States Code) involved in carrying out section 4 of the National Science Foundation Act of 1950, as amended (42 U.S.C. 1863) and Public Law 86-209 (42 U.S.C. 1880 et seq.), ~~$3,969,000:~~*$4,030,000: Provided*, That not to exceed ~~$9,000~~*$2,500* shall be available for official reception and representation expenses. *(Science Appropriations Act, 2008.)*

National Science Board

FY 2009 Summary Statement

(Dollars in Millions)

	Enacted/ Request	P.L. 110-161 Rescission	Expired	Total Resources	Obligations Incurred/Est.
FY 2007 Appropriation	$3.97	-	-$0.32	$3.65	$3.65
FY 2008 Estimate	3.97	-	-	3.97	3.97
FY 2009 Request	4.03	-	-	4.03	4.03
$ Change from FY 2008					$0.06
% Change from FY 2008					1.5%

Adjustment to Base

Within the Office of the National Science Board FY 2007 appropriation, a total unobligated balance of $314,068 expired.

Background on the National Science Board

As an independent federal agency, NSF does not fall under any cabinet department; rather NSF's activities are guided by the Board. The Board was established by the Congress both to serve as a national science policy body, and to oversee and guide the activities of NSF. It has dual responsibilities to: a) provide independent national science policy advice to the President and the Congress; and b) establish policies for NSF. The Board has 24 Members appointed by the President and confirmed by the Senate. Board Members, who serve 6-year terms in intermittent appointments, are drawn from industry and universities, and represent a variety of S&E disciplines and geographic areas. They are selected for their preeminence in research, education, or public service. The NSF Director is also a full voting member (*ex officio*) of the Board.

In recent years, the Board has met six times a year to review and approve major NSF awards and new programs, oversee and provide policy direction to NSF, and deal with significant science and engineering related national policy issues. It initiates and conducts studies and reports on a broad range of policy topics, and publishes occasional policy papers or statements on issues of importance to U.S. science and engineering. The Board analyzes NSF's budget to ensure progress and consistency along the strategic direction set for NSF and to ensure balance between new investments and core programs. It also identifies issues that are critical to NSF's future, and approves NSF's strategic budget directions and the annual budget submission to the Office of Management and Budget (OMB).

National Science Board Activities

Because it is required to establish the Foundation's policies within the framework of applicable national policies as set forth by the President and Congress, the Board supports the strategic Government Performance and Results Act (GPRA) goals of the Foundation and those identified in the President's Management Agenda (PMA). The Board conducts continuous assessment of the quality, relevance, and performance of the Foundation's award making, as called for in the Research and Development Investment Criteria of the PMA. The Board has received reports from the chairmen of the Foundation's Advisory Committee on GPRA Performance Assessment, reviews the summary results of the Foundation's annual performance goals, and approves the NSF Strategic Plans. The NSF Director's report on merit review is presented to the Board each year, allowing the Board to monitor the quality and effectiveness of this keystone Foundation process.

The Board issues policy guidance in the form of official statements and resolutions, and reports to the President and Congress dealing with topics such as the Foundation's merit review criteria, cost sharing with universities, science and engineering education, the science and technology workforce, and funding and oversight of major research infrastructure projects. The Board is responsible for direct review and approval of the largest Foundation awards, and is responsible for the review and approval of major research infrastructure projects at all stages of development, including budget planning, review of proposals and management effectiveness, and approval of awards.

The Board is authorized to establish committees, which advise the full Board as it exercises its statutory powers and functions. The standing Committee on Audit and Oversight oversees the operations of the Foundation's Office of Inspector General (OIG), as well as NSF compliance with new procedures for financial accountability and information technology security. The members of the Committee on Programs and Plans (CPP) review proposals for major awards, the health of the Foundation's peer review system, and program performance and accountability. The Board monitors the critical infrastructure that supports research in Antarctica through the CPP Subcommittee on Polar Issues.

The Board established a Committee on Strategy and Budget (CSB) in 2001 to focus on strategic planning and new investments for NSF. Review of the Foundation's budget request is also vested in CSB. The Committee on Education and Human Resources (EHR) focuses on Foundation activities in such priority areas as S&E workforce development, math and science education, and underrepresented populations and regions in S&E programs. The EHR Subcommittee on S&E Indicators manages the process for development and review of the Board's biennial statistical report, *Science and Engineering Indicators*. In FY 2008, the Board delivered *Science and Engineering Indicators 2008* to the President and to Congress, in keeping with its statutory responsibility.

During the last year, the Board accomplished a great deal in terms of its mission to provide oversight and policy directions to the Foundation, including: reviewed and endorsed the OIG Semi-annual Reports to Congress and approved NSF management responses; approved the NSF FY 2009 Budget Submission for transmittal to OMB; approved the Foundation's annual Merit Review Report; and provided review and decisions on major awards or proposal funding requests. In addition, the Board's report, *Enhancing Support of Transformative Research at the National Science Foundation* (NSB-07-32), provided guidance on the creation of a new NSF Transformative Research Initiative.

In terms of advice to the President and the Congress, the Board approved, published, and distributed the report, *HURRICANE WARNING: The Critical Need for a National Hurricane Research Initiative* (NSB-06-115). This report provides broad recommendations regarding our Nation's hurricane research enterprise, as well as specific guidance for the role that NSF should play in these efforts. The Board also received the report of its Commission on 21st Century Education in Science, Technology, Engineering and Mathematics (STEM) and developed a Board national action plan for addressing the critical STEM education needs of our Nation while providing specific guidance for the role of NSF in the national STEM education enterprise. The Board completed its national and international hearings and roundtable discussions to support its examination of the role of the federal government in supporting international S&E partnerships and plans to publish its findings and recommendations in FY 2008. The Board has provided testimony to Congress; interacted with the White House Office of Science and Technology Policy in meetings and forums on science and engineering issues; and responded to specific questions and inquiries from Senators and Representatives. Board meetings and deliberations continue to be open in accord with the Government in the Sunshine Act, as directed by the NSF Act of 2002. The Board continues to improve its outreach and communications with the Congress, other agencies, various interest groups and the outside science and engineering research and education community.

During FY 2008, the Subcommittee on Science and Engineering Indicators prepared a policy statement Companion Piece to *Science and Engineering Indicators 2008*, and produced a pilot volume of a Science and Engineering Indicators Digest, which will highlight a small selection of core and topical S&T, and serve as a portal to the electronic version of *Science and Engineering Indicators 2008*. The purpose of this new publication is to expand the audience for *Indicators*, make it more useful to policy-makers and facilitate access to data of interest in the main volumes of *Indicators*.

National Science Board FY 2009 Budget Request

The Board's FY 2009 Budget Request seeks resources to carry out its statutory authority and to strengthen the Board's oversight responsibilities for the Foundation. Enhanced Board responsibilities established in the NSF Authorization Act of 2002 (H.R. 4664), directed by Congressional report language and the NSF Authorization Act of 2007 (H.R. 2272), include the continued expanding role in prioritizing and approving

MREFC projects, audits for Sunshine Act Compliance, review of NSF policy with respect to cost sharing requirements in NSF awards, large facility pre-construction development, construction and post-construction operations and management costs, support for interdisciplinary research, and review of NSF policies limiting proposal submissions by institutions. In addition, by August 2010 the Board must submit to Congress a summary report of its findings, including any recommendations regarding changes to, the termination of, or the continuation of the NSF pilot program of grants for new investigators established under the 2007 Authorization.

Effective communications and interactions with our constituencies contribute to the Board's work of identifying priority science and technology issues, and developing policy advice and recommendations to the President and Congress. To this end, the Board will continue to increase communication and outreach with the university, industry, and the broader science and engineering research and education community, Congress, federal science and technology agencies, and the public. The Board's activities will aim to support U.S. global leadership in discovery and innovation based on a continually expanding and evolving science and technology enterprise in this country, and will ensure a principal role for NSF programs in providing a critical foundation for science and engineering research and education.

Several endeavors that the Board expects to formally complete by the end of FY 2008 will require significant follow-up outreach efforts by the Board in FY 2009 to ensure the desired impacts are realized. For example, lessons learned by the Board's experience with its 1982 STEM Education Commission report and the 2001 report on the role of the federal government in supporting international science, have provided clear and strong lessons on the importance of the Board undertaking significant follow-up efforts to ensure action based on their reports. While the Board will complete its Action Plan on 21st Century STEM Education in FY 2008, it is clear that much follow-up outreach by the Board will be required throughout FY 2009 to ensure the work of the Commission and the Board have the highest possible impact. Although many of these recommendations will be at a national system level, a number will focus specifically on the role NSF can and should play in supporting the development of an adequate and diverse science and engineering workforce and science literate population. The Board expects to be significantly engaged with oversight of NSF implementation of components of the Action Plan for STEM Education. The Board will also continue to review and approve NSF's actions for creating major NSF programs and funding, and expects new efforts to be implemented regarding enhancement of NSF support for potentially transformative research as a result of new Board guidance. Likewise, the Board's task force to review international S&E partnerships will complete its work in FY 2008, but will require significant follow-up by the Board in FY 2009.

The Board's new Digest for its biennial *S&E Indicator*s report in FY 2008 requires significant new outreach efforts on the part of the Board, as will the Board's policy statement Companion Piece accompanying the FY 2008 *Indicators*. Further, the Board will begin considering new content and indices for *Science and Engineering Indicators for 2010*, which will require significant efforts in 2009. Moreover, the Board will likely begin a new review effort focused on the S&E challenges related to development of alternative sustainable energy that will be continuing in FY 2009. In addition, the Board will continue to review and approve NSF's actions for creating major NSF programs and funding large projects, as well as dealing with evolving NSF policy issues. Experience has demonstrated that the Board will receive a number of requests from Congress asking that the Board examine and report quickly on a wide range of national policy topics related to S&E research and education. The Board welcomes such requests from Congress and the Administration, and will itself continue to identify high priority topics focused specifically on NSF, or more broadly on national S&E policy issues that it feels it should examine in FY 2009.

Essential to the conduct of Board business is a small and independent core of full-time senior policy, clerical, and operations staff, supplemented by temporary contractual support as needed for various Board endeavors.

In addition to the Board Office's essential and independent resources and capabilities, external advisory and assistance services continue to be critical to support production of Board reports and supplement the Board Office staff's general research and administration services to the Board. These external services provide the Board and its Office with the flexibility to respond independently, accurately, and quickly to requests from Congress and the President, and to address issues raised by the Board itself.

By statute the Board is authorized five professional positions and other clerical staff as necessary. In consultation with Congress, the Board has defined these five professional positions as Board Office senior S&E policy staff, and the clerical positions as Board Office staff that support operations and related activities associated with the conduct of Board meetings and oversight responsibilities. The Board Executive Officer, who reports directly to the Board Chairman, also serves as the Director of the Board Office. The Board Office staff provides both the independent resources and capabilities for coordinating and implementing S&E policy analyses and development, and the operational support that are essential for the Board to fulfill its mission.

Personnel Compensation and Benefits and General Operating Expenses
(Dollars in Thousands)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Personnel Compensation and Benefits	$1,870	$1,862	$1,920	$58	3.1%
Staff Development & Training	8	25	9	-16	-64.0%
Advisory & Assistance Services	707	1,218	1,371	153	12.6%
Other Services	549	180	166	-14	-7.8%
Travel & Transportation of Persons	383	500	500	0	-
Communications, Supplies and Equipment	128	175	61	-114	-65.1%
Representation Costs	9	9	3	-6	-66.7%
Total	$3,654	$3,969	$4,030	$61	1.5%

Totals may not add due to rounding.

OFFICE OF INSPECTOR GENERAL $13,100,000

The Appropriations Act that funds the National Science Foundation provides for a separate appropriation for NSF's Office of Inspector General (OIG). Accordingly, the FY 2009 Budget Request identifies the resources needed to support OIG, including amounts for personnel compensation and benefits, contract services, training, travel, supplies, materials, and equipment.

The FY 2009 Budget Request for OIG is $13.1 million, which represents an increase of $1.67 million over the FY 2008 Estimate of $11.43 million.

Office of Inspector General Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Personnel Compensation and Benefits	$8.71	$8.96	$9.56	$0.60	6.7%
Other Operating Expenses[1]	3.21	2.47	3.54	1.07	43.3%
Total	$11.92	$11.43	$13.10	$1.67	14.6%
Full-Time Equivalent Employment	67	63	64	1	1.6%

Totals may not add due to rounding.
[1] Includes the costs of the annual financial statements audit and the outsourcing of contracting services.

Appropriation Language

For necessary expenses of the Office of Inspector General as authorized by the Inspector General Act of 1978, as amended, ~~$11,427,000,~~*$13,100,000,* to remain available until September 30, ~~2009.~~*2010 (Science Appropriations Act, 2008.)*

Office of Inspector General
FY 2009 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Carryover/ Recoveries	P.L. 110-161 Rescission	Expired	Total Resources	Obligations Incurred/Est.
FY 2007 Appropriation	$11.43	$1.24	-	-$0.05	$12.62	$11.92
FY 2008 Estimate	11.43	0.71	-0.46		11.68	11.68
FY 2009 Request	13.10	-	-		13.10	13.10
$ Change from FY 2008						$1.42
% Change from FY 2008						12.2%

Totals may not add due to rounding.

Explanation of Carryover

Within the Office of Inspector General (OIG) appropriation, a total of $707,223 was carried forward into FY 2008 of which $457,308 is rescinded, as required under P.L. 110-161. The remaining $249,915 will fund priority audits that are contracted out and the forensic analysis support required for some OIG investigations.

OIG RESPONSIBILITIES

In February 1989, the National Science Board established OIG pursuant to the Inspector General Act Amendments of 1988. The statute confers on OIG the responsibility and authority to:

- Conduct and supervise audits of NSF programs and operations, including organizations that receive NSF funding.
- Conduct investigations concerning NSF programs and operations, including organizations that receive NSF funding.
- Evaluate allegations of research misconduct, such as fabrication, falsification, or plagiarism, involving individuals who participate in NSF-funded activities.
- Provide leadership, coordination, and policy recommendations for:
  - Promoting economy, efficiency, and effectiveness in the administration of NSF programs and operations, and
  - Preventing and detecting fraud and abuse in NSF programs and operations.
- Issue semiannual reports to the National Science Board and Congress to keep them informed about problems, recommended corrective actions, and progress being made in improving the management and conduct of NSF programs.

As set forth in the OIG Strategic Plan, the primary functions of the Office are audits, reviews, and investigations. To provide the diverse skills, training, and experience necessary to oversee NSF's varied programs, the OIG staff includes scientists, attorneys, certified public accountants, investigators, evaluators, and information technology specialists. The focus of an investigation, audit, or other review may be on a single entity or individual, an organization, a project involving multiple disciplines, or a broad program or functional area.

OIG performs audits of grants, contracts, and cooperative agreements funded by the Foundation's programs. The Office also conducts audits and reviews of both internal agency programs and external organizations that receive NSF funding to ensure that financial, administrative, and programmatic activities are conducted economically, effectively, and in compliance with agency and federal requirements. OIG is also responsible for overseeing the audit of the Foundation's annual financial statements, which are required for all NSF accounts and activities by the Government Management Reform Act of 1994. The Office contracts with a public accounting firm to conduct the financial statements audit, and in the past the cost was allocated proportionately to the accounts audited. Since FY 2006, funds to cover the complete cost of the financial audit have been requested in this appropriation. OIG also audits financial, budgetary, and data processing systems used by NSF to develop the financial statements. In addition, the

Office performs multi-disciplinary reviews – involving auditors, attorneys, management analysts, investigators, and others as needed – of financial, management, and program operations to identify broader problems and highlight best practices.

OIG investigates possible wrongdoing by organizations and individuals who submit proposals to, receive awards from, conduct business with, or work for the Foundation. Allegations of research misconduct are also investigated. OIG assesses the validity and seriousness of all the allegations it receives and recommends proportionate action. When appropriate, the Office refers the results of these investigations to the Department of Justice or other authorities for criminal prosecution, civil litigation, or resolution via settlement agreements and institutional compliance plans. OIG refers other cases to the Foundation for administrative resolution and, when appropriate, recommends modifications to agency policies and procedures to ensure the integrity in NSF's systems. The Office works closely with institutions on the conduct of their internal investigations and performs outreach activities aimed at preventing and detecting fraud, waste, and abuse and at raising the awareness of funded researchers, institutional administrators, and agency employees about the OIG's role and NSF's rules and expectations.

Personnel Compensation and Benefits and General Operating Expenses
(Dollars in Thousands)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Personnel Compensation and Benefits	$8,712	$8,964	$9,560	$596	6.6%
Travel & Transportation of Persons	253	270	310	40	14.8%
Advisory & Assistance Services[1]	2,753	1,978	2,930	952	48.1%
Communications, Supplies and Equipment, and Other Services	198	215	300	85	39.5%
Total	$11,916	$11,427	$13,100	$1,673	14.6%

Totals may not add due to rounding.

[1] Includes the costs of the annual financial statements audit and the outsourcing of contracting services.

The additional funds requested for FY 2009 are needed to cover increased personnel costs, one additional FTE, the rapidly rising costs of audits conducted by CPA firms under contract to OIG, and essential technology upgrades to replace aging personal computers, about two-thirds of which are over four years old, and to acquire software that will provide more efficient support for our investigations and audits. Personnel costs, which consume 70 percent of the annual OIG budget, have continued to rise. The last two years have also brought significantly higher costs in staff travel, which is essential for conducting investigations, audits, and meetings with counterparts in this country and abroad to share information and best practices and foster improved coordination of efforts. Finally, the requested funding will allow OIG to keep pace with the increased risks faced by NSF. While other agencies may primarily contend with other kinds of liabilities, NSF's greatest risk by far is its financial exposure in awarding billions of dollars in grants and contracts each year. As the agency's funding grows, so does this risk -- and the concomitant need for increased OIG oversight.

The additional FTE is needed to improve audit coverage of larger, and increasingly complex, interdisciplinary and collaborative NSF awards. The greatly increased demand in the marketplace for auditors due to the Sarbanes-Oxley legislation has severely impaired OIG's ability to hire and retain qualified grant auditors. To address this hiring issue, we would like to contract with the Office of

Personnel Management on ways to attract and retain staff with knowledge and expertise in these highly specialized areas. The requested funds would allow us to move this effort forward. In addition, OIG expects to convert to electronic workpapers in keeping with most other OIG and professional audit organizations, which will require an initial expenditure of more than $80,000, annual fees of 20 percent of the base cost, and the cost of training existing staff to use the new workpaper format.

The FY 2009 request would enable OIG to cover the significantly higher costs for outsourced audits conducted by CPA firms. Their average cost has increased 30 percent over the past few years, from approximately $100,000 per audit in FY 2004 to approximately $130,000 per audit in FY 2007, and they are expected to exceed $140,000 per audit in FY 2008. To ensure OIG independence and provide more efficient and timely servicing of contracting requirements, we will continue to use the Department of Treasury's business service center, Administrative Resource Center. For FY 2009, therefore, the additional funding requested will also cover the estimated $300,000 cost of outsourcing contract administration services that used to be performed by the NSF contracts office.

Increased resources would enable OIG to focus audits more effectively on the seven areas we have identified as posing the greatest risks to NSF: 1) pre-award and post-award monitoring of grants, contracts, and large facility projects, especially those that have experienced large cost overruns; 2) the human capital resources needed to process the more than 40,000 proposals submitted to the agency each year; 3) the merit review process, including such issues as (a) obtaining sufficient reviewers with the appropriate expertise to review proposals that are increasingly multidisciplinary and (b) increasing traditionally underrepresented groups in the reviewer pools; 4) NSF processes for ensuring the confidentiality of sensitive agency information, including personally identifiable information, and for building an enterprise architecture that will enable NSF to develop optimal information technology systems in the future; 5) the infrastructure for the United States Antarctic Program, which NSF manages, to ensure the health and safety of researchers and support personnel and to enable world-class research in such an extreme environment; 6) implementation of the new administrative requirements on financial reporting controls required by the Federal Managers Financial Integrity Act; and 7) the evaluation of NSF programs and the dissemination of NSF-funded research results.

In FY 2006 OIG had the resources to audit only five percent of the total $11 billion of NSF funds expended by awardees classified as high risk. The requested funding would enable audits of a larger percentage of risky awardees, provide more effective oversight of NSF programs, and promote the more efficient use of NSF grant funds. This level of funding would also allow for the major ongoing initiative to audit labor-effort costs charged to NSF awards by institutions receiving the most funding from NSF. Labor effort is the single largest cost in NSF awards, and it is frequently cited in audit reports for weak internal controls. OIG will also continue to focus attention on audits of international institutions, which are an increasingly important part of NSF's research portfolio but often are not subject to the terms and conditions of NSF's other awardees. Our efforts will be coordinated with other OIGs and international audit organizations to evaluate the need for developing standardized financial, accounting, and audit requirements for better accountability of funds provided by all sources.

In support of the American Competitiveness Initiative (ACI), OIG will help ensure that each additional dollar NSF invests in basic research is subject to appropriate oversight and sound management controls. With their emphasis on efficiency and effectiveness, OIG program audits support efforts to increase NSF's operational capacity at a reasonable cost to the taxpayer. Our audits continue to focus on many of the priorities identified in the ACI. For example, we are working on an audit of NSF centers, which facilitate collaboration on complex scientific projects, and of large-scale facilities and instruments, which enable discovery and development. Following the recommendations of prior OIG audits of large facilities, NSF is reengineering its approach to planning, building, and managing these projects. Our audits have also recommended improvements in the way NSF disseminates research results for the benefit of the research community. The changes will facilitate technology transfer, enhance researcher access to information useful for their own work, and accelerate the process by which basic research enables the introduction of successful new products. As NSF attempts to leverage its investments by entering into a growing number of international partnerships, OIG has played a leadership role in establishing a dialogue among international organizations responsible for science research funding to discuss strategies for addressing mutual accountability challenges.

The requested budget level will provide the resources that are needed to continue the expansion of OIG's Quality Control Reviews of the CPA firms conducting audits for grantees under the Single Audit Act (OMB Circular A-133). Because NSF relies extensively on these audits for post-award monitoring and financial statement reporting, it is critical that the quality of the audits be carefully assessed and that any deficiencies be corrected. In June 2007 the President's Council on Integrity and Efficiency and the Executive Council on Integrity and Efficiency (ECIE) published their *Report on National Single Audit Sampling Project*. It found that for entities expending at least $500,000 of federal awards, but less than $50 million, only 48 percent of the A-133 audits were acceptable.

The criminal, civil, administrative, and research misconduct cases conducted by our investigative staff have become increasingly more complex, requiring more extensive discussions and negotiations with NSF management, awardee administrators, international organizations, and the Department of Justice to bring them to a satisfactory resolution. Our civil and criminal cases frequently produce both financial settlements for institutional fraud and compliance agreements for correcting the underlying problems and providing greater protection for future federal funding. Monitoring institutions' efforts to meet the terms of their 5-year compliance plans is vital to preventing fraud from recurring, but it is also very time consuming for our staff. With the increase in the number of compliance programs in recent years, we have experienced a corresponding growth in staff hours committed to monitoring them. The systemic problems that have allowed fraud to occur take time to correct, and ongoing oversight is required to ensure that the flaws in the systems are not further exploited. The requested budget level will provide the additional resources needed to meet this critical requirement.

We will continue to initiate proactive reviews based on previous investigative findings. These reviews have identified institutions whose high-risk management practices created significant opportunities for institutional fraud, and they have resulted in improved institutional controls, recoveries, and new civil/criminal cases. Recent efforts have been successful in revealing the misuse of participant support, cost sharing, and expired award funds. These more complex, institution-wide efforts require increasing amounts of staff time and more frequent and extensive use of forensic financial services to develop persuasive investigative evidence.

We anticipate that cases handled in FY 2009, like current cases, will result in significant recoveries and critical system changes in institutions. Further, we expect concomitant improvements in institutional detection of fraud and greater assurance that federal funds will thereafter be put to proper use. Under our monitoring, the systemic changes will also promote higher ethical conduct in the application for and execution of federal awards. As in our compliance efforts, these cases require significantly more staff time, as well as specialized knowledge and strong forensic, computer and analytical skills.

Our investigative workload is also growing rapidly in other areas. Over the past year, we have seen a notable increase in serious data fabrication and falsification cases, which usually result in findings of research misconduct, and in international collaboration cases. The latter, in particular, require substantial resources to determine their scope and complexity and to perform the more-intricate investigations they require. Overall, in the past ten years we have experienced almost a four-fold increase in the number of matters we have reviewed, a more than 15-fold increase in actions related to cases (including financial recoveries, debarments, and DOJ actions), and a more than 20-fold increase in referrals to DOJ or other entities for investigation, prosecution, or recovery. The additional resources we have requested will allow us to pursue matters that threaten the integrity of NSF's systems more aggressively and meet the challenges inherent in the growing number, size, and complexity of NSF awards projected under the ACI.

OIG will continue its commitment to a strong outreach effort to educate NSF staff and the national and international research communities to help them avoid the kinds of problems that lead to investigations, unfavorable audit findings, or administrative corrective actions. This initiative is designed to make NSF staff, awardee institutions, international collaborators, and other researchers more aware of grant management issues and any preventive or corrective measures that may need to be taken. Auditors, investigators, and other staff regularly participate in outreach activities, and as NSF programs increase in funding, complexity, and number, OIG has seen a commensurate increase in requests for information from universities and research institutions. As in recent years, we will continue to play a leadership role in organizing and participating in international conferences and workshops, which have been well attended by NSF's counterparts in other countries, including their auditing and investigative components, to discuss common issues and share best practices.

We will also continue to work closely with other IG offices on issues that are of mutual concern. NSF's IG was honored to be appointed by OMB as Vice-Chair of the ECIE in May 2007. This leadership position serves the IG community, the administration, and the Congress, and it entails significant responsibilities that place demands on both the IG's time and office resources. Commitment of staff effort is necessary for a variety of IG community responsibilities, including analyzing legislation, planning and conducting ECIE meetings and initiatives, providing testimony, and responding to inquiries from the research community, the Congress, the public, and the press.

OIG's increasingly complex audits and investigations require significantly more staff time and contractor support than in the past, as well as specialized knowledge and strong forensic, IT systems, and analytical skills. This request will provide the resources needed to ensure diligent audits and investigations of the growing number of substantive complaints we are receiving and to enable us to respond to emerging situations, such as NSF's increasing reliance on computer information systems and security controls to process and report accurate grant and other financial information, changing audit standards, and challenges to NSF's cybersecurity at NSF, its funded institutions, and remote locations like Antarctica.

MAJOR MULTI-USER RESEARCH FACILITIES $1,106,400,000

The FY 2009 Request includes $1,106.40 million for major multi-user research facilities, a $25.51 million increase, or 2.4 percent, over the FY 2008 Estimate of $1,080.89 million. All operations and maintenance of multi-user facilities are funded through the Research and Related Activities (R&RA) account, and most major construction projects are funded through the Major Research Equipment and Facilities Construction (MREFC) account.

Major Multi-User Research Facilities Funding
(Dollars in Millions)

				Change over FY 2008 Estimate	
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Amount	Percent
Facilities	$832.60	$898.13	$907.51	$9.38	1.0%
Federally Funded R&D Centers	181.89	182.76	198.89	16.13	8.8%
Total, Major Multi-user Research Facilities	$1,014.49	$1,080.89	$1,106.40	$25.51	2.4%

Totals may not add due to rounding.

NSF investments provide state-of-the-art tools for research and education, such as multi-user research facilities, distributed instrumentation networks and arrays, accelerators, telescopes, research vessels, aircraft, and earthquake simulators. In addition, investments in internet-based and distributed user facilities are increasing as a result of rapid advances in computer, information, and communication technologies. NSF's investments are coordinated with those of other organizations, agencies, and countries to ensure complementarity and integration.

This chapter provides descriptions of each major multi-user research facility supported through the R&RA account and provides funding information by life cycle phase for each facility. The information presented for each facility follows the overall framework established by NSF for large facility projects. More information on the construction projects funded through NSF's MREFC account is provided in the MREFC chapter.

Major Multi-User Research Facilities Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Request
Academic Research Fleet	$87.95	$70.66	$83.96	$13.30	18.8%
Cornell Electron Storage Ring	14.71	13.71	8.50	-5.21	-38.0%
EarthScope[1]	11.63	17.61	26.29	8.68	49.3%
Gemini Observatory	20.00	20.00	22.00	2.00	10.0%
Incorporated Research Institutes for Seismology	11.77	11.75	12.20	0.45	3.8%
Integrated Ocean Drilling Program[2]	36.81	39.26	47.74	8.48	21.6%
Large Hadron Collider	18.00	18.00	18.00	-	-
Laser Interferometer Gravitational Wave Observatory	33.00	29.50	28.50	-1.00	-3.4%
National High Magnetic Field Laboratory	26.55	26.50	31.50	5.00	18.9%
National Nanotechnology Infrastructure Network	13.32	13.50	13.50	-	-
National Superconducting Cyclotron Laboratory	18.50	18.50	20.50	2.00	10.8%
Network for Earthquake Engineering Simulation	20.74	22.17	23.02	0.85	3.8%
Other Facilities[3]	12.57	12.47	19.47	7.00	56.1%
Polar Facilities and Logistics[4]	317.46	323.54	352.25	28.71	8.9%
MREFC Projects[5]	189.60	260.96	200.08	-60.88	-23.3%
Federally Funded R&D Centers[6]					
National Astronomy and Ionosphere Center	10.46	12.15	11.40	-0.75	-6.2%
National Center for Atmospheric Research	85.12	87.54	95.87	8.33	9.5%
National Optical Astronomy Observatory and the National Solar Observatory	39.28	38.55	41.83	3.28	8.5%
National Radio Astronomy Observatory	47.03	44.52	49.79	5.27	11.8%
Grand Total	$1,014.49	$1,080.89	$1,106.40	$25.51	2.4%

[1]EarthScope funding includes support provided through the R&RA account for operations and maintenance of the facility. Support provided through the MREFC account for the construction of the project, totaling $25.93 million in FY 2007, is included in the MREFC Projects line.
[2]Funding for the Integrated Ocean Drilling Program (IODP) includes support for the continued phase out of program and contract activities for the Ocean Drilling Program, predecessor to the IODP. This line also includes support for the operations and maintenance of the Scientific Ocean Drilling Vessel; MREFC funding for the SODV, the final year of which was FY 2007, is included on the MREFC projects line.
[3]"Other Facilities" includes support for other physics and materials research facilities.
[4]Polar Facilities and Logistics includes support for the operations and maintenance of the South Pole Station. Funds provided through the MREFC account for the South Pole Station Modernization (SPSM) project are included on the MREFC Projects line.
[5]Funding levels for MREFC Projects in this table include support for concept and development associated with these projects, initial support for operations and maintenance (both provided through the R&RA account), and implementation support provided through the MREFC account. EarthScope and SODV received the final year of construction funding in FY 2007, and those MREFC funds are included here.
[6]"Federally Funded R&D Centers" does not include the Science and Technology Policy Institute, which is an FFRDC but not a research platform.

Academic Research Fleet $87,960,000

The FY 2009 Budget Request for the Academic Research Fleet is $87.96 million, an increase of $14.80 million, or 20.2% over the FY 2008 Estimate of $73.16 million.

Academic Research Fleet
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Academic Research Fleet	$87.95	$73.16	$87.96	$14.80	20.2%

The Academic Research Fleet consists of 23 vessels in the University-National Oceanographic Laboratory System (UNOLS). These vessels range in size, endurance, and capabilities, enabling NSF and other federally funded scientists with the means to conduct ocean science research with a diverse fleet capable of operating in coastal and open ocean waters. Funding for the Academic Research Fleet includes investments in ship operations; shipboard scientific support equipment; oceanographic instrumentation and technical services; and submersible support. In addition, the Division of Ocean Sciences (OCE) has undertaken selected construction projects, based on an inter-agency fleet renewal status plan.

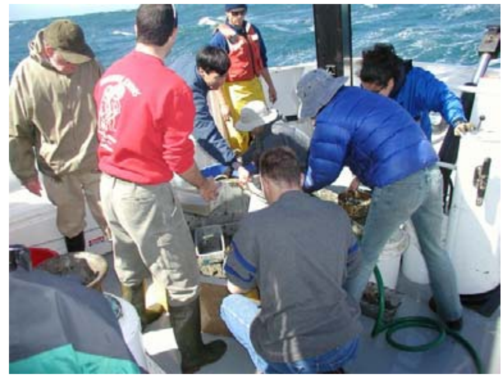
Total Obligations for the Academic Research Fleet
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$76.63	$66.16	$72.96	$93.92	$99.55	$105.52	$111.86	$118.57
Fleet Renewal:								
Human Occupied Vehicle	9.05	1.00	1.00	-	-	-	-	-
R/V Langseth (Seismic Ship)	0.69	2.00	-	-	-	-	-	-
Regional Class Research Vessels	1.57	4.00	14.00	20.00	20.00	20.00	20.00	20.00
Total, Academic Research Fleet	$87.95	$73.16	$87.96	$113.92	$119.55	$125.52	$131.86	$138.57

The Academic Research Fleet serves as the main platform for the collection of data and testing of hypotheses about the structure and dynamics of the oceans. Scientists contribute to advances made in areas such as climate variability, marine ecosystems, fisheries, and ocean-related natural hazards such as tsunamis through use of these facilities. Vessels in the Academic Research Fleet permit shipboard training of future oceanographers. Participating graduate and undergraduate students interact with scientists and marine technicians, enabling them to gain first-hand exposure to ocean science field research. Recent technological innovations allow research conducted at sea to be transmitted via satellite back to the classroom, broadening the educational impact of the vessels to a wider audience, including K-12 students.

The Academic Research Fleet is supported through an interagency partnership, principally with the National Oceanic and Atmospheric Administration (NOAA) and the Office of Naval Research (ONR) via a Memorandum of Understanding (MOU). The operating costs for the Fleet are divided proportionally among the vessel users based on usage; NSF supports approximately 70 percent of the total. NSF also coordinates with ship-operating and ship-user academic institutions through UNOLS.

Support for scientists using the fleet is provided by both NSF and other state and federal agencies. Within NSF, science is supported via competitive peer-reviewed proposals, most typically funded within OCE and through selected programs in the Divisions of Earth Sciences (EAR) and Atmospheric Sciences (ATM), and also through the Office of Polar Programs (OPP) and the Directorate for Biological Sciences (BIO). Approximately 30 percent of the GEO proposals request ship time; GEO-funded shipboard science has ranged from about $35 million to $45 million per year over the last 5 years. Not reflected in this number is the science that utilizes samples or data collected on prior cruises, scientists piggy-backing on scheduled cruises to accomplish additional science, international scientists sailing with the U.S. fleet, and science funded by other agencies.



This is an image of a marine ecology class cruise for graduate students on the *Point Sur*, a ship owned by the NSF and operated by the Moss Landing Marine Laboratories (MLML) of the California State University System. for graduate students. The students are examining the contents of the trawl taken from a ridge near the mouth of the Monterey Bay at a depth of just over 500 meters.

Project Report:

<u>Management and Oversight:</u>

- Fleet Operations:
  - NSF provides oversight to the Academic Research Fleet through cooperative agreements with each ship-operating institution and the UNOLS Office. In addition, NSF oversees the fleet through external review of proposals, site visits, ship inspections, and participation at UNOLS Council and Subcommittee meetings by Program Managers. Several Program Managers within OCE at NSF, at NOAA, and at ONR are involved in the activities and overall oversight of the Academic Research Fleet.
  - Management of an individual institution's ship-operating facilities varies with the scale of the operation, but the core responsibility typically resides with the Director of the Institution, the Marine Superintendent (for all aspects of the facility), and the Ship's Captain (for at-sea operations). For larger multi-ship-operating institutions, a chief of marine technicians, schedulers, and finance administrators may also be involved in facility management.
- Fleet Renewal:
  - The NSF coordinator is the program director for Ship Acquisitions and Upgrades, within the Integrative Programs Section (IPS) in OCE, with additional IPS staff providing project management assistance.
  - External Structure: NSF and the Navy's Program Executive Office Ships (PEO Ships) are negotiating a new MOU to extend the cooperative relationship for the acquisition of the Regional Class Research Vessels (RCRVs) beyond the design phase. NSF and PEO Ships jointly manage the program, with PEO Ships (NAVSEA) serving as the contracting authority and providing the required personnel with expertise in ship design and acquisition, teamed with NSF personnel and other sources under a cost reimbursable agreement with NSF. In addition, a team of UNOLS Marine Superintendents and Technicians participated in Phase I of a multi-phase design process.

The UNOLS Fleet Improvement Committee will review progress and provide advice regarding scientific outfitting of the vessel.

- Reviews Conducted: Based on projected science requirements identified in recent reports and workshops, a fleet of vessels supporting ocean science research will be needed far into the future. In coordination with the other federal agencies with ocean research investments and UNOLS, the Interagency Working Group for Facilities (IWG-F) has revised the 2001 report on long-range plans for renewal of the federal and academic oceanographic research and survey fleet and it will be published this year. In addition, several activities are requested or underway to support the upgrade of the U.S. Academic Research Fleet. Ship operations and technical activities are internally reviewed yearly on the basis of detailed annual reports provided by the operating institutions. Ship operations proposals undergo external merit review every five years, with annual negotiation of the cooperative agreements. Technical services awards are reviewed every three years and negotiated annually.

<u>Fleet Renewal: Current Status:</u>

- Ongoing activity in FY 2009 includes:

  - Continued development and construction of a new deep submergence capability to replace the pioneering submersible human occupied vehicle (HOV) ALVIN. This project, begun in FY 2004, will take a total of six years and cost approximately $22.0 million; an increase over previous estimates due to rise in titanium costs.
  - A design competition is underway for construction of a series of up to three Regional Class Research Vessels (RCRVs), and two U.S. shipyard/design agent consortia are working to each produce a design and bid on construction by summer 2009.
  - Outfitting of the Research Vessel (R/V) *Langseth* will be completed in FY 2009.

Renewal/Recompetition/Termination: The R/V *Alpha Helix*, which previously supported research activities in the Alaska region, was sold by the University of Alaska for $680,000. Funds are being held by the institution pending direction from NSF on proper use of those funds. Potential uses include future operation support of the Alaska Region Research Vessel and instrumentation development for this new vessel. This 40 year old *Alpha Helix* was the oldest in the fleet and was in use well beyond the normal lifetime of a research vessel.

Cornell Electron Storage Ring $8,500,000

The FY 2009 Budget Request for the Cornell Electron Storage Ring (CESR) is $8.50 million, a decrease of $5.21 million, or 38.0 percent, from the FY 2008 Estimate of $13.71 million.

Cornell Electron Storage Ring
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Cornell Electron Storage Ring	$14.71	$13.71	$8.50	-$5.21	-38.0%

CESR is a facility that supports research in elementary particle physics as well as research in accelerator physics and superconducting radio frequency (RF) applications. The funding profile presented above is targeted toward the planned close-out of the particle physics program based upon the CESR accelerator.

With the closeout of the particle physics program at CESR, physicists at Cornell, building upon their technical and analytical expertise, are ramping up their participation in the research program of the Compact Muon Solenoid (CMS) experiment, one of the two major detectors at the CERN Large Hadron Collider (LHC). During this final funding period, a vigorous program of accelerator science and technology development for accelerator concepts for the future will continue.

CESR is an electron-positron collider that provides important knowledge of the properties of the b-quark. A modified CESR (CESR-c) and the associated particle detector, CLEO-c, address high-priority physics questions that relate to the c-quark and possible gluon states that cannot be addressed elsewhere. The CESR facility is also used by the materials research community at the Cornell High Energy Synchrotron Source (CHESS). CHESS is a high-intensity, high-energy X-ray source supported by NSF. It uses the synchrotron light given off by the charged particles, both electrons and positrons, as they circulate at nearly the speed of light around CESR. As a user facility, CHESS provides state-of-the-art synchrotron radiation facilities for research in physics, chemistry, biology, materials research and environmental sciences.

Total Obligations for CESR
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$14.71	$13.71	$8.50	-	-	-	-	-

CESR-c and CLEO-c explore a large set of critical weak and strong interaction phenomena that drive theoretical advances that extend and enable the full program of physics targeted by new-generation detectors and lay the foundation for strong interaction theory to meet the requirements of future physics beyond the Standard Model. It is expected that that the CESR-c and CLEO-c projects will cease by the close of FY 2009 as the Large Hadron Collider (LHC) begins operations. Scientific research at CESR supports and enhances doctorate level graduate education, postdoctoral research experience, research experiences for undergraduates, and research experiences for K-12 science teachers. Engendering excitement in science among young children is a focus for K-12 engagements. An important component of this effort is the participation of CLEO and CESR graduate students in school science classrooms.

CESR staff transfers CESR Superconducting RF (SRF) technology to industry. Through a license arrangement with Cornell, the ACCEL Corporation has manufactured two superconducting RF sources to power synchrotron light sources. They have been tested and installed in CESR to replace two older, lower gradient modules. Also, some of the CHESS users are from industry, including pharmaceutical corporations (Rib-x Pharmaceuticals) and the research arms of Eastman Kodak, Xerox and General Motors. Some medical institutions also make use of CHESS (Dana Farber Cancer Institute, Boston Biomedical Research Institute, and Memorial Sloan-Kettering Institute).

Project Report:

<u>Management and Oversight:</u>

- NSF Structure: NSF oversight is provided through the Division of Physics (PHY) of the Directorate for Mathematical and Physical Sciences (MPS) and by periodic site visits by NSF staff. Technical review of the award involved panel evaluation of the CESR-c proposal, and a site visit by NSF staff and external reviewers. The oversight process includes annual financial reports and program reports to the NSF and an annual review by a Program Advisory Committee of outside physicists reporting to the Laboratory Director and NSF.

  CHESS is supported through the Division of Materials Research (DMR) of MPS, the Directorate for Biological Sciences (BIO), and by the National Institutes of Health (NIH). These organizations provide management oversight for CHESS through regular site visits.

- External Structure: CESR-c is managed by the Director of the Laboratory for Elementary Particle Physics (LEPP) at Cornell with help from an Assistant Director and an Associate Director for Accelerator Physics. The CLEO-c experiment is the sole experiment in particle physics at CESR-c, and this collaboration consists of users from about 20 U.S. institutions. The CESR-c management interacts with the CLEO-c collaboration through the collaboration spokesperson and executive board as needed, and there are monthly meetings of the collaboration that include CESR-c management.

- Reviews:
  - Reviews Conducted:
    - Proposal review for continued operations, FY 2003
    - Comprehensive site review with panel of external experts, FY 2006
  - Upcoming:
    - Review for phase-out of facility operations, FY 2008

<u>Renewal/Recompetition/Termination:</u>

CESR is currently funded through the five-year cooperative agreement initiated in April 2003. Use of CESR as a facility for particle physics will conclude with final phase-out over FY 2008 and FY 2009. Proposals for the continuation of CHESS as a user facility for synchrotron radiation after the phase-out of the particle physics program are presently under consideration.

EarthScope $26,290,000

The FY 2009 Budget Request for EarthScope is $26.29 million, an increase of $8.68 million, or 49.3 percent over the FY 2008 Estimate of $17.61 million. FY 2007 represented the final year of MREFC appropriations for the EarthScope project; no funds are requested in FY 2009 through the MREFC account. Construction continues through FY 2008.

EarthScope
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
EarthScope	$37.55	$17.61	$26.29	$8.68	49.3%

The EarthScope Facility is a distributed, multi-purpose geophysical instrument array that is making major advances in our knowledge and understanding of the structure and dynamics of the North American continent. EarthScope instrumentation is expected to be located in nearly every county within the U.S. over the life span of the program.

Total Obligations for EarthScope
(Dollars in Millions)

	Prior Years	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
R&RA Obligations:									
Concept & Development	9.36	-							
Management and Operations	13.51	11.63	17.61	26.29	25.00	25.50	26.00	26.50	27.00
Subtotal, R&RA Obligations	$22.87	$11.63	$17.61	$26.29	$25.00	$25.50	$26.00	$26.50	$27.00
MREFC Obligations:									
Implementation	170.04	25.93	4.21	-					
Subtotal, MREFC Obligations	$170.04	$25.93	$4.21	-	-	-	-	-	-
Total: EarthScope Obligations	**$192.91**	**$37.55**	**$21.82**	**$26.29**	**$25.00**	**$25.50**	**$26.00**	**$26.50**	**$27.00**

EarthScope seeks to enhance the understanding of the structure and evolution of the North American continent, including earthquakes and seismic hazards, magmatic systems and volcanic hazards, lithospheric dynamics, regional tectonics, continental structure and evolution, fluids in the crust, and associated educational aspects. Science and non-science students will be engaged in geosciences discovery through the use of technology in real time or retrospectively with the aim of integrating research and education.

The U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), and the International Continental Scientific Drilling Programme are funding partners, with USGS and NASA expected as operating partners. Project partners may also include state and local governments, geological and engineering firms, and Canadian and Mexican agencies. Over 3,000 earth scientists and students are expected to use the facility annually. Geotechnical and engineering firms directly use data and models, which are enabled by EarthScope. Instrumentation firms are collaborating on development for state-of-the-art seismic systems, down-hole instrumentation, and high-precision GPS antenna designs.

Along with direct operations and maintenance support for the EarthScope Facility, NSF will support research performed utilizing the facility through ongoing research and education programs. The annual support for such activities is estimated to be about $15.0 million once the facility reaches full operations in FY 2009.

The project continues to move forward approximately on time and within budget, with completion anticipated by the close of FY 2008.

Project Report:

Management and Oversight:

- NSF Structure: The EarthScope Program Director, located in the Earth Sciences (EAR) Division in the Directorate for Geosciences (GEO), provides NSF oversight. The Deep Earth Processes Section Head (EAR) and a Project Advisory Team, including the staff from GEO, the Office of the General Counsel (OGC) and staff from the Office of Budget, Finance and Award Management (BFA), including the Deputy Director for Large Facility Projects, provide other internal oversight.

- External Structure: Following the recommendations of the Large Facilities Management and Oversight guideline documents, external oversight is provided through periodic reviews, including facility construction project baseline reviews and ad hoc technical, science, and education and outreach committee meetings, as well as site visits.

- Reviews: The EarthScope facilities are formally reviewed annually during the construction phase, with NSF and EarthScope's managers conducting a combined site visit and review of each of the three components. Each November, NSF convenes a panel of external experts to review project management, cost, schedule, and technical status of the EarthScope facilities and provide advice for the EarthScope managers and NSF.

Current Project Status:

The third and final phase of drilling was conducted at the San Andreas Fault Observatory at Depth (SAFOD) site during 2007. Tens of feet of continuous core was collected across the active traces of the San Andreas Fault system. Research on the core is just beginning. The Plate Boundary Observatory (PBO) has installed more than 770 permanent geodetic stations, 30 borehole strainmeter stations, and three long-baseline strainmeters. The USArray has installed more than 400 Transportable Array stations, and installations continue on schedule. Other highlights include the combined use of PBO geodetic and strain data and USArray seismic data in analyses of "slow earthquakes" in the Cascadia subduction system. The

A remote EarthScope instrument installation.
Credit: EarthScope.

EarthScope project has been represented at several dozen professional meetings and conferences through an exhibit booth, presentations, and scientific sessions. Scientific results utilizing data collected by the EarthScope facility have already been presented at national meetings and in professional publications.

Cost, Schedule, and Risks

- As of October 31, 2007, EarthScope was 4 percent behind schedule and 2 percent under budget for the work completed. Eighty two percent of the planned construction of the EarthScope facility is complete. Overall, the effort is almost exactly on budget and on schedule.

- There are no remaining major risks to a successful completion of the construction of EarthScope; however, some minor risks associated with fluctuating shallow drilling costs and permitting issues for some equipment installations remain.

Operations costs

These costs are anticipated to remain approximately steady at about $24 million, with adjustments for inflationary effects. The 2009 Request exceeds this level as the FY 2008 Estimate does not fully support the targeted operation level through FY 2009.

Gemini Observatory $22,000,000

The FY 2009 Budget Request for the Gemini Observatory is $22.00 million, an increase of $1.50 million, or 7.3%, above the FY 2008 Enacted Level of $20.50 million.

Gemini Observatory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Gemini Observatory	$20.00	$20.50	$22.00	$1.50	7.3%

The Gemini Observatory consists of two 8-meter telescopes, one in the northern hemisphere, in Hawaii, and one in the southern hemisphere, in Chile. The Hawaiian telescope, Gemini North, is optimized for infrared observations and is located on Mauna Kea at an altitude of 4,200 meters. The telescope in Chile, Gemini South, is located on Cerro Pachon, also an outstanding photometric site, at an altitude of 2,700 meters. This siting of the two telescopes assures complete coverage of the sky and complements the observations from space-based observatories. It provides access to the center of our own Galaxy as well as the Magellanic Clouds, our nearest galactic neighbors. Both telescopes are designed to produce superb image quality and both use sophisticated adaptive optics technology to compensate for the blurring effects of the Earth's atmosphere.

Total Obligations for the Gemini Observatory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$20.00	$20.50	$22.00	$25.66	$26.17	$26.70	$27.25	$27.80

Astronomers need to resolve important questions about the age and rate of expansion of the universe, its overall topology, the epoch of galaxy formation, the evolution of galaxies once they are formed, and the formation of stars and planetary systems. The new generation of optical/infrared telescopes with significantly larger aperture (8-meter diameter) than previous instruments provides better sensitivity and spectral and spatial resolution. Technological advances in a number of key areas of telescope construction and design optimize the telescopes' imaging capabilities and infrared performance, and compensate for the blurring effects of the earth's atmosphere.

The Gemini telescopes play a central role in the education and training of U.S. astronomy and engineering students. An estimated 10 percent of the roughly 500 U.S. users per year are students. Gemini is also providing a focus for public outreach and high school student training in all the partner countries, including "sister city" arrangements between Hilo, Hawaii and La Serena, Chile involving students and teachers at high school and elementary school levels. Gemini staff also provides guidance and support to the Imiloa Science Center, a public astronomy and cultural center in Hilo.

Gemini is an international partnership with the United Kingdom, Canada, Australia, Chile, Argentina, and Brazil. Construction of the telescopes and their instrumentation has involved a large number of industrial entities in a number of partner and non-partner countries. These have involved firms specializing in large and/or complex optical systems, aerospace industries, electronics and engineering, etc. Continued involvement of such industries is part of the instrumentation and facilities renewal activities included in the operating budget of the Gemini Observatory.

Peer-review telescope allocation committees provide merit-based telescope time but no financial support. NSF does not provide awards targeted specifically for use of Gemini. Many U.S. users are supported through NSF or NASA grants to pursue scientific programs that require use of Gemini.

This image shows the Gemini North Telescope on the evening of April 19th, 2005 during evening twilight. Featured on the foreground of the telescope is the laser guide star (LGS) clean-room (blue box with white door). The Gemini solid-state sodium laser is located in this box and shines up through a network of tubes and relay optics (also visible) where the beam is "launched" by optics located behind the secondary mirror. *Credit: Gemini Observatory*

Laser guide star systems, which greatly improve the telescopes' ability to correct for atmospheric blurring, are being developed for both telescopes with the laser on Gemini North in routine operation and integration of the system on Gemini South underway. An advanced 'multi-conjugate' adaptive optics system, which will yield crisp images over a larger field of view, is in development on Gemini South and will start scientific operation in FY 2009. Several new instruments are in various states of development, including: (1) an improved infrared spectrometer, to be delivered in FY 2008; (2) the construction of the Gemini Planet Imager, a camera designed to directly detect planets around nearby stars; and (3) design studies for a very wide-field optical spectrometer that will collect data from thousands of objects simultaneously.

Changes in the budget profile from the FY 2008 Enacted Level are a result of the availability and inclusion of more realistic estimates of partner countries' funding for next generation instrumentation. Projections for FY 2010 and beyond also reflect the decision on the part of the United Kingdom (UK) to withdraw from the partnership. While the final disposition of the UK share is under discussion, the likely outcome is that it will be split between the U.S. and Australia. The FY 2010 estimate reflects an increase in the U.S. share of Gemini from 50.1% to 65%. Final disposition of the UK share should be determined in mid-2008.

Facility Report

<u>Management and Oversight:</u>

- NSF Structure: Programmatic management is the responsibility of an assigned program manager for Gemini in the Division of Astronomical Sciences in MPS.

- External Structure: The Observatory is governed by the Gemini Board, established by the International Gemini Agreement signed by the participating agencies. NSF serves as the Executive Agency for the seven-nation partnership, carrying out the project on their behalf. An independent Visiting Committee, established by the Gemini Board, advises on the operation of the Observatory and meets bi-annually. Gemini is managed by Associated Universities for Research in Astronomy

(AURA), Inc. on behalf of the partnership through a cooperative agreement with NSF. AURA conducts its own management reviews through standing oversight committees.

- Reviews: In addition to a review held mid-way through the cooperative agreement, NSF conducts periodic reviews of AURA management and observatory programs as requested by the Gemini Board. The observatory's adaptive optics program was reviewed by an external committee in September 2007, and the computing and data reduction program was reviewed in December 2007.

Renewal/Recompetition/Termination:

Under the terms of the international agreement, the partnership conducted a management review in 2004 and determined that it would not compete the management of the Observatory at that time. A cooperative agreement for the period FY 2006-2010 is currently in place. A mid-term management review of AURA's performance will be conducted in fall 2008, on the basis of which the Gemini Board will decide whether to compete the management of the observatory.

The current International Gemini Agreement will expire in 2012. The Gemini Board has begun the discussion of the process and schedule for renegotiation of the Agreement, given the UK's recent decision to withdraw.

Incorporated Research Institutions for Seismology $12,200,000

The FY 2009 Budget Request for Incorporated Research Institutions for Seismology (IRIS) is $12.20 million, an increase of $450,000, or 3.8 percent, over the FY 2008 Estimate of $11.75 million.

Incorporated Research Institutions for Seismology
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Incorporated Research Institutions for Seismology	$11.77	$11.75	$12.20	$0.45	3.8%

IRIS is a consortium of 104 U.S. universities and non-profit institutions with research and teaching programs in seismology. IRIS operates a distributed national facility for the development, deployment, and operational support of modern digital seismic instrumentation to serve national goals in basic research in the earth sciences, in earthquake research, and in nuclear test ban monitoring. IRIS is also leading the construction of the USArray component of the EarthScope project.

Total Obligations for IRIS
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$11.77	$11.75	$12.20	$12.50	$12.80	$13.10	$13.50	$13.90

The Earth's interior remains a major scientific frontier holding the key to understanding the origin of the planet. Recent developments in seismic sensor design, and the acquisition, transmission, and storage of data have resulted in dramatic improvements in the resolving power of seismic imaging of the interior. To serve the research needs of the broad national and international seismology community, IRIS is organized in four major program elements:

1. The Global Seismographic Network (GSN), which currently consists of a global deployment of over 140 permanently installed digital seismic stations, most of which have real-time data access;
2. The Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL), which manages a pool of portable seismometers that are made available to the seismology research community for scheduled regional and local scale studies;
3. The IRIS Data Management System (DMS), which provides the national and international seismic research community with timely access to data from the GSN and PASSCAL (70 terabyte archive); and
4. The IRIS Education and Outreach (E&O) Program, which enables audiences beyond seismologists to access and use seismological data and research for educational purposes, including teacher workshops, student internships, museum exhibits, educational materials, and programs for under-resourced schools.

In addition to its role in providing the observational data essential for basic research in geophysics and earthquake dynamics, IRIS plays a significant role in seismic monitoring of the Comprehensive Test Ban Treaty, and in bringing seismology to students and the public through the activities of its education and outreach program.

IRIS is heavily involved in partnership activities, many international in nature. Installation and operation of the GSN has put IRIS in contact with scientists as well as government and non-government organizations from around the world. Many international IRIS GSN stations are designated as the official stations for nuclear test ban monitoring in their host countries. The IRIS facilities also are multi-use resources for other government agencies that have responsibilities for development of a nuclear test-ban monitoring capability and for monitoring global seismicity. For these purposes, agencies in partnership with NSF have provided substantial support to IRIS for accelerated development of the GSN (Department of Defense), shared operation and maintenance of the GSN (U.S. Geological Survey), and accelerated development of the PASSCAL instrument pool (Department of Energy).

The use of IRIS PASSCAL instruments for investigations of the shallow crust provides opportunities for collaboration with the petroleum exploration industry. Many students involved in these experiments receive training in techniques that prepare them for careers in the exploration industry. In a broader sense, IRIS continues to collaborate closely with industry in development of seismic instrumentation and software.

The EAR/Geophysics, Tectonics, and Continental Dynamics Programs; the OCE/Marine Geology and Geophysics Program; and the OPP/Antarctic Research Section (Geology and Geophysics and Glaciology Programs) provide most of the funds for NSF-sponsored research making use of the IRIS facilities, totaling approximately $15 million per year. Funds permit deployment of PASSCAL instruments and use of GSN data stored at the DMS to solve major earth science problems.

This is an image of the entrance to the Global Seismic Network's seismic vault on Tristan da Cunha in the South Atlantic. This station is part of a collaboration with the Comprehensive Test Ban Treaty Organization International Monitoring System and Geoscope. *Credit: Ted Kromer.*

Facility Report:

<u>Management and Oversight</u>

- NSF Structure: The Division of Earth Sciences (in GEO), through its Instrumentation & Facilities Program (IF), provides IRIS with general oversight to help assure effective performance and administration. The program also facilitates coordination of IRIS programs and projects with other NSF-supported facilities and projects and with other federal agencies and evaluates and reviews the scientific and administrative performance of IRIS.

- External Structure: IRIS is incorporated as a non-profit consortium representing practically all U.S. university and non-profit organizations with research and teaching programs in seismology. Each member institution appoints a representative. However, all IRIS program and budget decisions are made by a nine-member Board of Directors. These decisions are made after consultation with the IRIS advisory committees (the four standing committees for each of the four IRIS programs and additional ad hoc working groups appointed for special tasks). The Board of Directors appoints a president of IRIS to a two-year term. The president is responsible for IRIS operations, all of which are managed through the IRIS Corporate Office.

- Reviews & Renewal: All major ongoing geoscience facilities routinely undergo mid-award reviews of their management in addition to peer review of proposals for new or continued support. The recent and planned review schedule for IRIS is outlined below.

- Reviews:
  - Management review: March, 2004.
  - Renewal proposal reviewed, cooperative agreement awarded: May, 2006
  - Upcoming: Mid-award review, 2009

<u>Renewal/Recompetition/Termination:</u>

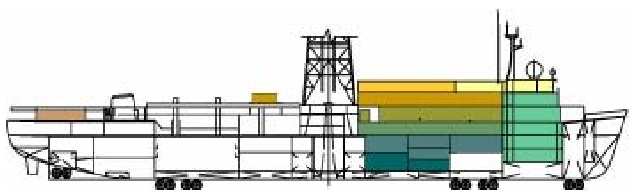
An NSF review of IRIS management in coordination with IRIS and its appropriate governance committees was completed in 2004. This review provided more information for the basis of the decision to allow the submission of a renewal proposal rather than to recompete the operation of this facility. A new five-year cooperative agreement with the IRIS Consortium for the continued management of the IRIS facilities (2006-2011) was approved by the NSB in May 2006 and finalized in September 2006.

The Integrated Ocean Drilling Program for use of the Scientific Ocean Drilling Vessel — $47,740,000

The FY 2009 Budget Request for operation of the Integrated Ocean Drilling Program (IODP) is $47.74 million, an increase of $8.48 million, or 21.6 percent, over the FY 2008 Estimate of $39.26 million. FY 2007 represented the final year of MREFC appropriations for the SODV project; no funds are requested through that account in FY 2009.

The Integrated Ocean Drilling Program
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Integrated Ocean Drilling Program	$34.71	$39.26	$47.74	$8.48	21.6%



The Integrated Ocean Drilling Program (IODP), which began in FY 2004, is an expanded successor program to the Ocean Drilling Program (ODP) and represents an international partnership of more than 20 national funding organizations, scientists, and research institutions organized to explore the evolution and structure of Earth as recorded in the ocean basins. The IODP is co-led by NSF and the Ministry of Education, Culture, Sport, Science and Technology (MEXT) of Japan. IODP platforms provide sediment and rock samples (cores), in-situ monitoring, sampling, and measurement from borehole observatories, shipboard and shorebased descriptive and analytical facilities, downhole geophysical and geochemical measurements (logging), and opportunities to conduct experiments to determine in-situ conditions beneath the seafloor.

Total Obligations for IODP Facility Operations
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$34.71	$39.26	$47.74	$49.65	$51.64	$53.70	$55.85	$58.08

The IODP Scientific program includes emphasis on the following research themes:

- Deep Biosphere and the Sub-seafloor Ocean.
- Processes and Effects of Environmental Change.
- Solid Earth Cycles and Geodynamics, including study of tsunami-producing seismogenic zones and other geohazards.

Undergraduate and graduate students participate in drilling expeditions, working with leading scientists to help become future leaders themselves. Other students and the public are engaged in geoscience discovery through distance learning initiatives (including remote broadcasts from the drillship), classroom teaching modules on IODP research initiatives, outreach displays for museums and educational/teaching institutions, and lecture programs. In FY 2007, an estimated 180,000 K-12, 10,000 undergraduate and 10,500 graduate students engaged in or were supported by IODP education and outreach efforts, as were 35,000 teachers.

MEXT and NSF are equal partners in IODP and contribute equally to program operation costs. The European Consortium for Ocean Research Drilling (ECORD) – representing 16 European countries and Canada – the People's Republic of China, and Korea have officially joined IODP and provide financial contributions. India and Australia have also announced their intention to join the partnership. IODP partners, including NSF, support IODP integrative activities including science planning, review, data management, drilling science-related engineering development, core and sample archiving, publishing, and international outreach.

Over 2,000 scientists from 40 nations have participated on ODP and IODP expeditions since 1985, including about 900 U.S. scientists from over 150 universities, government agencies, and industrial research laboratories. Samples and data have been distributed to more than 800 additional U.S. scientists.

NSF is contracting the services of the light drillship from a leading offshore drilling contractor. A commercial contractor provides downhole-logging services. In addition, scientists from industrial research laboratories propose and participate in IODP cruises, are members of the program's scientific and technical advisory committees, and supply data for planning expeditions and interpretation of drilling results.

The Scientific Ocean Drilling Vessel *JOIDES Resolution* in drydock at the Jurong Shipyard in Singapore undergoes blasting and painting in July 2007. *Credit: NSF.*

Operations and maintenance support for IODP includes the costs of operating the platform itself, providing technical scientific support, maintaining data bases and preparing scientific publications emerging from IODP expeditions, and management of the international program. In addition, NSF will support research enabled by the facility, through ongoing research and education programs. The annual costs for such science support are estimated to be about $11 million. Operations and maintenance costs are based on NSF experience in management of the ODP and the contract with the Scientific Ocean Drilling (SODV) operator.

Facility Report:

Management and Oversight:

- NSF Structure: The Division of Ocean Sciences (in GEO) manages the SODV and the IODP under the NSF Ocean Drilling Program. NSF's Ocean Drilling Program is located within the Marine Geosciences Section, with several program officers dedicated to its oversight. One of the program officers serves as the contracting officer's technical representative on the Central Management Office (CMO) and System Integration Contractor (SIC) contracts.

- External Structure: NSF and MEXT have signed a Memorandum of Cooperation, which identifies procedures for joint management of a contract to an IODP CMO. The CMO coordinates and supports scientific planning, drilling platform activity, data and sample distribution, and publication and outreach activities through its management of commingled international science funds, collected and provided by NSF. A non-profit corporation of U.S., Japanese, and other international institutions (IODP Management International, Inc.) has been contracted by NSF for the CMO activity. Drillship providers are responsible for platform operational management and costs. NSF provides the light drillship through contract with the U.S. SIC, an alliance formed by the Consortium for Ocean Leadership, Inc. (COL) together with subcontractors Texas A&M University and Lamont-Doherty Earth Observatory, Columbia University. MEXT manages its drillship through the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), while the British Geological Survey manages ECORD drilling contributions.

Scientific advice and guidance for IODP is provided through the scientific advisory structure (SAS). The SAS consists of a Science Advisory Structure Executive Committee (SASEC) and a series of committees, panels, and groups headed by the Science Planning Committee (SPC). The CMO, under the direction of the SPC Chair, is responsible for the coordination of the SAS committees, panels, and groups, and for integrating the advice from the advisory structure in a manner suitable for providing drilling and operational guidance to the CMO. Membership in the SAS is proportional to IODP member's financial contribution.

- Reviews: Both the CMO and SIC contracts call for management reviews every three years by independent, external panels. The SIC contract is scheduled to undergo external review in FY 2008, with the CMO contract to undergo external review in FY 2009. In addition, NSF is conducting Business System Reviews of both contracts in the FY 2008- FY 2009 timeframe. Reviews for each expedition are carried out on a regular basis to evaluate operational and scientific performance.

<u>Renewal/Recompetition/Termination:</u>

IODP international agreements and contracts cover activities through FY 2013. Activities regarding IODP renewal, including overall program review, are expected to commence in FY 2011.

<u>Scientific Ocean Drilling Vessel (SODV)</u>

The SODV project was funded through the MREFC account and supported the contracting, conversion, outfitting and acceptance trials of a deep-sea drilling vessel for long-term use in the IODP. The outfitted drillship will be capable of operating in nearly all ocean environments, subject to limitations regarding minimum water depth and surface ice coverage. It will be able to accommodate a scientific and technical staff of up to 60 persons. FY 2007 represented the final year of appropriations for the SODV project. Construction activities will continue into early FY 2008.

Appropriated MREFC Funds for the SODV
(Dollars in Millions)

FY 2005	FY 2006	FY 2007	Total
$14.88	$57.23	$42.88	$115.00

Totals may not add due to rounding.

<u>Baseline History</u>: NSF first requested $40.85 million for the first year of a two year construction phase of the SODV in FY 2005. The total estimated cost of the project was $100.79 million. Congress appropriated $14.88 million in FY 2005, and a contract for refit and operation of the SODV was awarded in 2005. A preliminary baseline was established during a June 2006 Review for NSF and the SODV

Independent Oversight Committee in response to the shift in the anticipated funding stream. The baseline could not be fully defined at that time since the cost of a principal element of the project, the shipyard conversion contract, was not yet available. During FY 2007, it was necessary to make significant adjustments to the proposed design in order to remain within the requested budget, reducing the overall length of the ship, but still making possible renovations and significant enhancements to the laboratory space, science instrumentation, propulsion capabilities, and the number of available scientific berths on-board Following contract award in 2007, a SODV Baseline Review Panel was convened by NSF, and the formal baseline was established and integrated into the Earned Value Management Reporting System used to track actual performance against planned baseline.

Project Report:

Management and Oversight:

- NSF Structure: The project is overseen by a program director in the Division of Ocean Sciences in the Directorate for Geosciences. The program director receives advice and oversight support from a NSF Project Advisory Team, which consists of representatives from GEO, the Office of Polar Programs, the Office of Budget, Finance and Award Management, and the Office of General Counsel. The BFA Deputy Director for Large Facility Projects is a member of the PAT and provides advice and assistance.

- External Structure: A SODV Independent Oversight Committee provides technical, financial and scheduling recommendations and advice for the SODV project to top-level management. A Program Advisory Committee (PAC), composed of members of the science and drilling communities, provides ongoing assessment of the design plans for the on-board science and drilling capabilities, which will serve to assure that the converted vessel reflects the needs of the scientific communities.

- Reviews:
  - Technical reviews: A final acceptance review process will be performed by the contractor responsible for the ship conversion activity as well as NSF.

Current Project Status:

In September 2003, NSF awarded a contract to Joint Oceanographic Institutions, Inc. (JOI [now the Consortium for Oceanographic Leadership, COL]) for IODP drilling operations, which includes the planning and implementation of the SODV project. JOI issued a request for proposals (RFP) to acquire, upgrade, and operate a commercial vessel for scientific ocean drilling. The contract was awarded to Overseas Drilling Limited in December 2005. The SODV Project received a total NSF contribution of $115 million; the ship operator, ODL, is providing an additional $15 million of construction costs in exchange for a higher day rate charge during the operations phase. Shipyard conversion of the vessel is currently underway, with a contract delivery date of March 31, 2008.

Cost and Schedule:

The SODV ship is currently being refitted in the shipyard under a fixed price contract. Work is more than three quarters complete, and the ship is expected to ready to conduct research in mid 2008, about one-half year later than originally planned. Due to the enormous worldwide demand for shipyard services, the shipyard work progressed more slowly than originally planned.

Risks

Principal risks at this stage of the project are Shipyard Cost Growth, Science Equipment Test and Integration, and Shipyard Schedule. A risk management plan is in place and highest level risks are reviewed continuously by the SODV Conversion Management Team and regularly by the SODV Independent Oversight Committee.

Future Operations Costs: Future operations costs are described in the IODP section above.

Large Hadron Collider $18,000,000

The FY 2009 Budget Request for the Large Hadron Collider (LHC) is $18.0 million, level with the FY 2008 Estimate of $18.0 million.

The Large Hadron Collider
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Large Hadron Collider	$18.00	$18.00	$18.00	-	-

The LHC, an international project under construction at the CERN laboratory in Geneva, Switzerland, will be the premier facility in the world for research in elementary particle physics. The facility will consist of a superconducting particle accelerator providing two, counter-rotating beams of protons, each beam having an energy up to 7 TeV (1TeV=10^{12} electron volts). The U.S. is involved in the maintenance and operation of two particle detectors, a Toroidal LHC Apparatus (ATLAS) and the Compact Muon Solenoid (CMS) that have been built to characterize the different reaction products produced in the very high-energy proton-proton collisions that will occur in intersection regions where the two beams are brought together. A total of 34 international funding agencies participate in the ATLAS detector project, and 31 in the CMS detector project. NSF and the Department of Energy (DOE) are providing U.S. support. CERN is responsible for meeting the goals of the international LHC project. The ATLAS and CMS detectors are expected to take data approximately 200 days per year. The remaining time is to be used for maintenance and testing.

The U.S. LHC collaboration has been a leader in the development of Grid-based computing. The Grid will enable the enhanced participation of U.S. universities, and thus the training of students, in both state of the art science and computational techniques, in a project that is centered overseas. The Grid is expected to have broad application throughout the scientific and engineering communities.

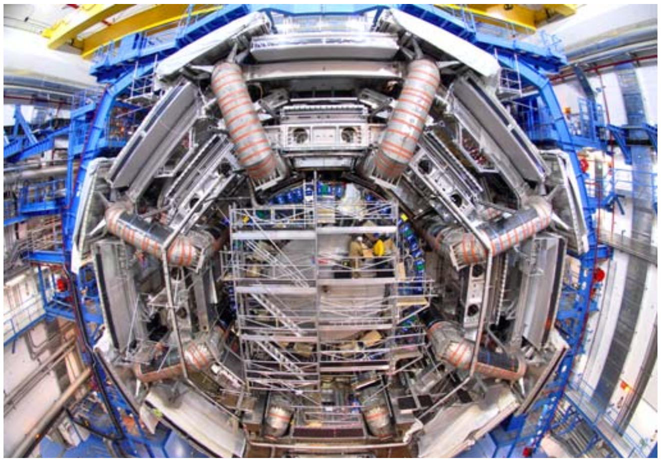
Total Obligations for the LHC
(Dollars in Millions)

	FY 2007	FY 2008	FY 2009	ESTIMATES				
	Actual	Estimate	Request	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00

The LHC will enable a search for the Higgs particle, the existence and properties of which will provide a deeper understanding of the origin of mass of known elementary particles. The LHC will also enable a search for particles predicted by a powerful theoretical framework known as supersymmetry, which will provide clues as to how the four known forces evolved from different aspects of the same 'unified' force in the early universe, and can investigate the possibility that there are extra dimensions in the structure of the universe. Through the participation of young investigators, graduate students, undergraduates, and minority institutions in this international project, LHC serves the goal of helping to produce a diverse, globally-oriented workforce of scientists and engineers. Further, innovative education and outreach activities, such as the QuarkNet project, allow high school teachers and students to participate in this project (see the URL: http://quarknet.fnal.gov). Many highly-trained students in high-energy physics move into industrial jobs.

Major procurements of components of both warm and superconducting magnets, as well as high-speed electronics, are performed through U.S. industries. Major developments in Grid computing are also valuable outcomes. In the construction phase, approximately $45 million was devoted to materials procurements from industry. In FY 2009, the estimate for material procurements is approximately $4 million, which is included within the $18 million operating costs.

The U.S. LHC Collaboration is in the midst of completing the installation of detector components in the experimental areas and has begun the integration of these components with the rest of the detectors and the commissioning of the detectors using cosmic rays. This effort is proceeding on schedule and on budget. First beams from the accelerator are expected in late FY 2008, after which the detector commissioning will proceed using the particle beams and will continue into FY 2009. Data-taking is expected to begin in FY 2009 when the beam performance stabilizes.



The ATLAS detector in February 2007. *Credit: CERN.*

Facility Report:

Management and Oversight:

- NSF Structure: A program director in the Division of Physics (PHY) is responsible for day-to-day project oversight. The NSF program director also participates in an internal Project Advisory Team, including staff from the Offices of Budget Finance and Award Management, General Counsel, Legislative and Public Affairs, the Office of International Science and Engineering, and the Office of the Assistant Director for MPS.

- External Structure: U.S. LHC program management is performed through a Joint Oversight Group (JOG), created by the NSF and DOE. The JOG has the responsibility to see that the U.S. LHC Program is effectively managed and executed to meet commitments made under the LHC International Agreement and its Protocols.

- Reviews: There is one major management/technical review each year with a panel of external, international experts as well as one review by NSF/DOE program directors to monitor the progress on issues raised at the panel reviews. In addition, there are two JOG review meetings per year to monitor overall program management.

Renewal/Recompetition/Termination:

The LHC project is expected to continue at least through to the end of the next decade. Since the present award goes through FY 2011, it will require a renewal. The U.S. LHC collaboration is part of an international collaboration where the U.S. contribution to the detector construction and operations is intimately connected to that of its international collaborators. Under these circumstances it would be difficult, if not unrealistic, to consider recompeting the U.S. role in the international collaboration when the present award ends.

Laser Interferometer Gravity Wave Observatory $28,500,000

The FY 2009 Budget Request for the Laser Interferometer Gravity Wave Observatory (LIGO) is $28.50 million, a decrease of $1.0 million, or 3.4 percent, from the FY 2008 Estimate of $29.50 million.

The Laser Interferometer Gravitational Wave Observatory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
LIGO	$33.00	$29.50	$28.50	-$1.00	-3.4%

Einstein's theory of general relativity predicts that cataclysmic processes involving extremely dense objects in the universe will produce gravitational radiation. Detection of these gravitational waves is of great importance for both fundamental physics and astrophysics. LIGO, the most sensitive gravitational wave detector ever built, comprises two main facilities, one in Livingston Parish, LA and one in Hanford, WA. At each facility, a large vacuum chamber, with two 4-km arms joined at right angles, houses one or more optical interferometers; Hanford has a second interferometer in the same housing. The interferometers are used to measure minute changes in the distances between test masses at the ends of the arms caused by a passing gravitational wave. The predicted distortion of space caused by a gravitational wave from a likely type of source is on the order of one part in 10^{21}, meaning that the expected change in the apparent 4-km length is only on the order of 4×10^{-18} or about 1/1000th the size of a proton. The 4-km length for LIGO, by far the largest for any optical interferometer, was chosen to make the expected signal as large as possible within terrestrial constraints. Looking for coincident signals in all the interferometers simultaneously increases the likelihood for gravitational wave detection.

LIGO's current and projected operations and maintenance requests for FYs 2008 through 2012 are less than the FY 2007 Current Plan since some employees and resources will be diverted to the Advanced LIGO (AdvLIGO) Major Research Equipment and Facilities Construction (MREFC) account project, requested as a new start in FY 2008. LIGO operations will, however, continue to analyze data taken during the current and earlier runs and will plan for and conduct future scientific runs until the scheduled shutdown of the detectors in FYs 2010-2011.

Total Obligations for LIGO
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$33.00	$29.50	$28.50	$28.50	$29.00	$31.00	$33.00	$36.00

Of the four known fundamental forces of nature – electromagnetic, weak, strong, and gravitational – the gravitational force is the most enigmatic. It is by far the weakest, yet it holds the universe together, ignites the fusion reaction in stars, and curves space in black holes so severely that light is trapped. Furthermore, even though the universe is believed to be filled with gravitational waves, not only from a host of cataclysmic cosmic phenomena but from the Big Bang itself, we have never detected a gravitational wave nor measured its waveform. The principal scientific goals of LIGO are to detect gravitational waves for the first time and to develop this capability into a new window on the universe, a window through which we can observe phenomena such as the inspiral and coalescence of neutron stars in binary orbit, black hole collisions, unstable dynamics of newborn neutron stars, supernovae, stochastic background from the early universe, and a host of more exotic or unanticipated processes.

LIGO has been a significant source of highly trained Ph.D. graduates for the country's workforce. The number of graduate students has grown from the beginning of LIGO's science runs in FY 2002 and will continue to do so. In addition, LIGO has a diverse set of educational activities at its different sites, activities that involve a large number of undergraduates (including those from minority-serving institutions), hands-on activities for K-12 classes, teachers at all levels, and informal education and outreach activities for the public. A Visitor Center at the Livingston, LA site, dedicated in November, 2006, is filled with Exploratorium exhibits and is the focal point for augmenting teacher education at Southern University and other student-teacher activities state-wide through the Louisiana Systemic Initiative Program, originally funded by NSF.

Substantial connections with industry have been required for the state-of-the-art construction and measurements involved in the LIGO projects. Some have led to new products. Areas of involvement include novel techniques for fabrication of LIGO's vacuum system, seismic isolation techniques, ultrastable laser development (new product introduced), development of new ultra-fine optics polishing techniques, and optical inspection equipment (new product). LIGO has recently cooperated with the Defense Intelligence Agency on research on LIGO interferometers as impulse seismic event detectors.

A recent image of the LIGO Science Education Center in Louisiana. *Credit: LIGO*

In 1997 LIGO founded the LIGO Scientific Collaboration (LSC) to organize the major international groups doing research that was supportive of LIGO. The LSC now has more than 40 collaborating institutions with over 500 participating scientists. A Memorandum of Understanding (MOU) between the LIGO Laboratory and each institution determines the role and membership responsibilities of each participating institution. The LSC plays a major role in many aspects of the LIGO effort including: R&D for detector improvements, R&D for AdvLIGO, data analysis and validation of scientific results, and setting priorities for instrumental improvements at the LIGO facilities. Annual NSF support for science and engineering research directly related to LIGO activities through ongoing research and education programs is estimated to be about $5.5 million.

LIGO concluded its mission-defining scientific run (S5), in which a year's accumulation of data is being taken with all three interferometers operating in coincidence, in October, 2007. These data were taken at a detector sensitivity in excess of the defined goal sensitivity outlined in the design specifications. Science runs planned to begin in 2009 will test technologies that will become part of AdvLIGO; the detector sensitivity will be at least twice that during the current S5 run.

LIGO's operations during the AdvLIGO construction era will concentrate on:

- Planning for and operation of "enhanced" initial LIGO in FYs 2008-2011;
- Research and Development to reduce risk for the AdvLIGO project, to enhance performance post-construction and to enable future enhancements.
- Data analysis and other science activities by staff of the LIGO Laboratory.
- Education and Outreach activities; and

- Ramp-up of AdvLIGO commissioning activities.

For more information on AdvLIGO, see the MREFC chapter.

Facility Report:

Management and Oversight:

- NSF Structure: NSF oversight is coordinated internally by the LIGO Program Director in the Division of Physics, who also participates in the Physics Division AdvLIGO Project Advisory Team, comprising staff from the Office of General Counsel, the Office of Legislative and Public Affairs, the Office of Budget, Finance and Award Management, including the Deputy Director for Large Facility Projects, and the Office of International Science and Engineering.

- External Structure: LIGO is sponsored by NSF and managed by Caltech under a cooperative agreement. The management plan specifies significant involvement by the user community, represented by the LIGO Scientific Collaboration (LSC), and collaboration with the other major gravitational-wave detector activities in Japan, Europe, and Australia. External peer-review committees organized by the NSF help provide oversight through an annual review.

- Reviews conducted:
  - Advanced LIGO Baseline Review, May-June 2006
  - LIGO Annual Review, November 2006
  - Advanced LIGO Baseline Update Review, June 2007
  - LIGO Annual Review and LIGO FY 2009-2013 Operations Proposal Review, November 2007

Renewal/Recompetition/Termination:

LIGO's current operations cooperative agreement expires at the end of FY 2008. LIGO has submitted a proposal for continued operations, and a review of that proposal was conducted in November 2007. An Action Item for continued support of LIGO operations will be submitted to the National Science Board in FY 2008 for a FY 2009 start.

Major Research Equipment and Facilities Construction Account Projects

The MREFC account supports the acquisition, construction and commissioning of major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering. Projects supported by this account are intended to extend the boundaries of technology and open new avenues for discovery for the science and engineering community. Initial planning and design, and follow on operations and maintenance costs of the facilities are provided through the Research and Related Activities (R&RA) and Education and Human Resources (EHR) accounts.

For information on projects funded through this account, please see the MREFC chapter in this document.

National High Magnetic Field Laboratory **$31,500,000**

The FY 2009 Budget Request for the National High Magnetic Field Laboratory (NHMFL) is $31.50 million, an increase of $5.0 million, or 18.9 percent, over the FY 2008 Estimate of $26.50 million.

The National High Magnetic Field Laboratory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
NHMFL	$26.55	$26.50	$31.50	$5.00	18.9%

The NHMFL is operated by Florida State University (FSU), the University of Florida (UF), and Los Alamos National Laboratory (LANL). The Laboratory develops and operates high magnetic field facilities that scientists and engineers use for research in physics, biology, bioengineering, chemistry, geochemistry, biochemistry, materials science, medicine, and engineering. It is the world's premier high magnetic field laboratory with a comprehensive assortment of high-performing magnet systems. Many of the unique magnet systems were designed, developed, and built by the magnet engineering and design team at the NHMFL in collaboration with industry. The facilities are available to all qualified scientists and engineers through a peer-review proposal process. The additional funding requested in FY 2009 will support magnet development, new instrumentation, planned facility upgrades, and support of in-house high impact research and development.

Total Obligations for the NHMFL
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$26.55	$26.50	$31.50	$33.00	$34.00	$34.00	$35.00	$35.50

Estimates from FY 2010-12 reflect the anticipated budget schedule based on the NSB approved 5-year (2008-2012) renewal award (August 8, 2007, NSB-07-78). Estimates for FY 2013-14 are dependent on the outcome of a renewal or recompetition in FY 2012.

The principal scientific goals of NHMFL are to provide the highest magnetic fields, state-of-the-art instrumentation, and support services for scientific research conducted by users from a wide range of disciplines, including all areas of science and engineering. In addition, the laboratory is an internationally recognized leader in state of the art magnet design, development, and construction. The Magnet Science and Technology (MS&T) Division of the NHMFL has broad responsibility to develop high field magnets and conducting and superconducting materials for future generation magnet wires in response to national needs. MS&T cooperates with industry and other international magnet laboratories on a variety of technology projects. These projects cover the range of analysis, design, materials, component development and testing, coil fabrication, cryogenics, system integration and testing.

Current magnet development at NHMFL is focusing on design and construction of high field magnets for the Nation's premier neutron and light sources. The laboratory has collaborated with more than 60 private sector companies including American Magnetics, Exxon Mobil Corporation, and Oxford Instruments; national laboratories and federal centers including major national laboratories supported by the Department of Energy such as the Spallation Neutron Source and the Advanced Photon Source.

International collaboration includes magnet development with the Hahn-Meitner Institute in Berlin and the Korea Basic Science Institute.

The NHMFL, with its distinguished faculty and world-class facilities, provides a unique interdisciplinary learning environment. Its annual K-12 outreach efforts engage over 7000 students from Florida and neighboring Georgia in hands-on science activities and tours of the laboratory. The research experiences for teachers and students plant seeds for developing the next generation of scientists, engineers, and science education leaders. In addition the NHMFL conducts a College Outreach-Workforce Initiative (CO-WIN) Program to increase diversity in the NHMFL programs. This has included outreach to approximately 200 undergraduates at Historically Black Colleges and Universities (HCBUs).

Facility Report

Management and Oversight:

- NSF Structure: The NHMFL is supported by the Division of Materials Research and the Division of Chemistry in the Mathematical and Physical Science Directorate. Primary responsibility for NSF administration and oversight of the NHMFL is the responsibility of the National Facilities Program Director in NSF's Division of Materials Research with guidance from an ad hoc working group with representatives from the Division of Chemistry in MPS, the Directorate for Engineering (ENG), and the Directorate for Biological Sciences (BIO). Site visit reviews are conducted annually. Representatives from other federal agencies including the Department of Energy (DOE) and the National Institutes of Health (NIH) are invited to participate as observers at the site visit reviews.

- External Structure: The NHMFL is operated for the NSF by a consortium of institutions comprised of FSU, UF, and LANL under a cooperative agreement that sets forth the goals and objectives of the NHMFL. FSU, as the signatory of the cooperative agreement, has the responsibility for establishing and maintaining appropriate administrative and financial oversight and for ensuring that the operations of the laboratory are of high quality and consistent with the broad objectives of the cooperative agreement. The principal investigator serves as the director of the NHMFL. Four senior faculty members serve as co-principal investigators.

  The NHMFL director receives guidance and recommendations from an External Advisory Committee, the NHMFL Executive Committee, NHMFL staff, the participating institutions, and the Users' Committee.

- Reviews: NSF conducts annual reviews using external reviewers. The reviews assess the user programs (access and service), the in-house research programs, the long-term plans of the NHMFL to contribute significant research developments both nationally and internationally, and the operations, maintenance and new development of its facilities. The annual reviews also assess the status of education training and outreach, the efficiency of operations and management of the facility, and the diversity plan. Specific reviews include:
  - Annual Review by program panel, March 2, 2005
  - Standard Award Monitoring Visit from DGA Annual Schedule, November 15-17, 2005
  - Annual Review by program panel December 4-6, 2005
  - Reviews by NSF Advisory Panel of Future Support for High Magnetic Fields, April 1st, April 21-22, April 23, and April 28, 2005
  - Renewal Review, January 9-11, 2007
  - Business Systems Review, planned, Spring 2008

- Annual Program Review, planned, September 2008

Renewal/Recompetition/Termination:

The current cooperative agreement for the support of NHMFL operations expires on December 31, 2007. A comprehensive renewal review was conducted during FY 2007. On August 8, 2007 the National Science Board approved NSF's recommendation for a 5-year renewal award not to exceed $162 million for 2008-2012. The new cooperative agreement becomes effective on January 1, 2008 and expires on December 31, 2012. This award will allow the NHMFL to increase its user program, continue the development of new magnet systems, and support the strongest aspects of its in-house research proposal, and ensures that the Laboratory will remain the international leader in magnet research operations and development.

National Nanotechnology Infrastructure Network **$13,500,000**

The FY 2009 Budget Request for the National Nanotechnology Infrastructure Network (NNIN) is $13.50 million, equal to the FY 2008 Estimate.

National Nanotechnology Infrastructure Network
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimated Amount	Change over FY 2008 Estimated Percent
National Nanotechnology Infrastructure Network	$13.32	$13.50	$13.50	-	0.0%

The National Nanotechnology Infrastructure Network comprises 13 university sites that form an integrated national network of user facilities supporting research and education in nanoscale science, engineering, and technology. The NNIN provides users across the nation with access, both on-site and remotely, to leading-edge tools, instrumentation, and capabilities for fabrication, synthesis, characterization, design, simulation, and integration. The broad scope of NNIN coverage includes areas of physics, chemistry, materials, mechanical systems, geosciences, biology, life sciences, electronics, optics, molecular synthesis, and molecular scale devices, among others.

Total Obligations for NNIN
(Dollars in Millions)

	FY 2007	FY 2008	FY 2009	ESTIMATES				
	Actual	Estimate	Request	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$13.32	$13.50	$13.50	$14.00	$14.32	$14.65	$14.99	$15.33

NNIN's broad-based national user facilities enable the nation's researchers from academia, small and large industry, and government to pursue transformative research, to seek new discoveries and applications in a broad range of domains of nanoscale science and engineering, and to stimulate technological innovation. The network also develops the infrastructure and intellectual and institutional capacity needed to examine and address societal and ethical implications of nanotechnology, including issues of environment, health and safety.

NNIN undertakes on a national scale a broad spectrum of innovative activities in education, human resource development, knowledge transfer, and outreach to the science, engineering, and technological communities. Special emphasis is placed on education and training of a diverse science and engineering workforce that involves non-traditional users and under-represented groups, including women and minorities.

NNIN seeks to leverage its capabilities through connections and collaborations with national and industrial laboratories, and with foreign institutions. Through such partnerships, joint meetings, and workshops, the network shares expertise and perspectives, provides specialized training opportunities, coordinates access to unique instrumentation, and transfers newly developed technologies.

NNIN leverages research strengths of the university to bring them to the external community. The institutions comprising the NNIN have strong underlying internal research programs that provide critical research mass and knowledge base in developing new processes, methodologies, and instrumentation, as well as providing much of the capital infrastructure. NSF and other agencies independently award research grants to principal investigators who use the NNIN facilities to carry out some aspects of their research projects.

NNIN continues to maintain a strong network-wide Research Experience for Undergraduates (REU) program. In FY 2007, 70 undergraduate students participated in the REU program, with at least 5 REU students at each of 12 sites. Student support was provided through an NSF REU site award, use of NNIN base funds, and industry funds. A REU Convocation was held at the end of the summer in which students from all NNIN sites gathered at one site for a 3-day technical symposium with their peers.

Nanooze, the kids' webzine on Nanotechnology produced by NNIN, was started in 2005 and has articles, interviews, the latest in science discoveries and even games. Content is delivered in a factual but informal style to create a medium friendly to young inquiring minds. *Nanooze* is currently published in English, Spanish and Portuguese and has a world-wide readership. *Credit: NNIN.*

Now in its fourth year of operation, NNIN is focused on eliminating barriers to ensure a large diversity of research ideas and users. The major portion of NSF funds provides for operation and staffing of the user facilities and associated network activities. Funds also provide for acquisition and for in-house development of appropriate instrumentation, tools, and processes to serve the user needs. This year the cumulative number of users for all NNIN sites increased by 9% over the previous reporting year to 4437, which included 3668 academic users (primarily graduate students, as well as undergraduates and postdoctoral associates), 473 small company users, and 210 large company users. It is estimated that over $400 million in research investment nationwide is leveraged by use of NNIN facilities. Most interestingly, many start-ups and small companies have chosen to utilize NNIN facilities as prototyping labs for developing new commercial ideas.

Facility Report:

<u>Management and oversight:</u>

- NSF structure: NSF provides oversight of the NNIN under a cooperative agreement. The program officer for the NNIN activity resides in the Division of Electrical, Communications and Cyber Systems (ECCS) in the Directorate for Engineering (ENG). The program officer coordinates NNIN oversight with the NNIN working group comprised of representatives from all NSF research and education directorates. NNIN is reviewed annually through site reviews held at one of the network sites. These reviews involve an external team of experts selected by NSF staff. In addition to the annual site reviews, semi-annual briefings of NSF staff are held at the NSF attended by the NNIN Network Director, Site Directors, and area Coordinators.

- External structure: NNIN is managed as a cohesive and flexible network partnership through a Network Executive Committee derived from the individual Site Directors, and the Education/Outreach and Society/Ethics Coordinators. The Network Director, who is from the lead institution, Cornell University, provides intellectual leadership for the network; is responsible, in cooperation with the Network Executive Committee, for developing strategies, operational plans, and coordination of the activities of the network; and serves as the principal contact on behalf of the network with the NSF. An external Network Advisory Board meets at least annually and provides independent advice and guidance to the Network Director and Executive Committee concerning the network's programs, activities, vision, funding allocations, and new directions. The Advisory Board shares its major recommendations with the NSF. The Site Directors are responsible for local management functions of the individual user facilities, for interfacing with other facilities and with the management team for the overall network, and for connections with the outside communities.

- Reviews Conducted:
  - The first comprehensive annual review of the NNIN was held following an initial 9 months of operation at the Georgia Institute of Technology site in December 2004. The second annual review was held at the University of Texas-Austin site in February 2006. The third annual review was held at the University of Michigan site in May 2007.
  - Upcoming reviews: A fourth annual review is planned for mid-2008. This review will serve also to evaluate the NNIN renewal proposal for the period FY 2009-2113.

Renewal/Recompetition/Termination:

As provided in the National Science Board award recommendation, the NNIN cooperative agreement may be renewed once, without recompetition, for an additional 5 years, subject to satisfactory review of performance and availability of funds. The maximum duration of the award is for 10 years. A renewal proposal is expected to be submitted in early 2008 for the five-year period FY 2009-2113.

National Superconducting Cyclotron Laboratory $20,500,000

The FY 2009 Budget Request for the National Superconducting Cyclotron Laboratory (NSCL) is $20.50 million, an increase of $2.0 million, or 10.8 percent, over the FY 2008 Estimate of $18.50 million.

National Superconducting Cyclotron Laboratory
(Dollars in Millions)

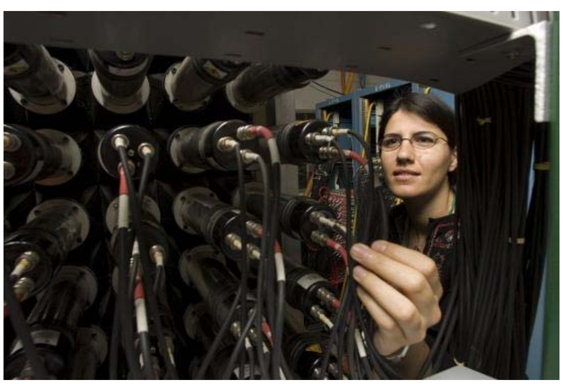
The National Superconducting Cyclotron Laboratory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
The National Superconducting Cyclotron Laboratory	$18.50	$18.50	$20.50	$2.00	10.8%

The NSCL at Michigan State University (MSU) is a national user facility. With two superconducting cyclotrons, K500 and K1200, it is the leading rare isotope research facility in the U.S. and is among the world leaders in heavy ion nuclear physics and nuclear physics with radioactive beams. Funding for the NSCL also supports the MSU research program. The $2.0 million increase in FY 2009 includes $1.0 million to compensate for requested funds in FY 2008 that were not appropriated. The full FY 2009 Request will support the increasing costs of maintaining the infrastructure as well as increasing personnel costs.

Total Obligations for the NSCL
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$18.50	$18.50	$20.50	$21.00	$21.50	$22.00	$22.50	$23.00



An NSCL research associate adjusts cabling on a detector. *Credit: NSCL.*

NSCL scientists employ a wide range of tools for conducting advanced research in fundamental nuclear science, nuclear astrophysics, and accelerator physics. Applications of the research conducted at the NSCL benefit society in numerous areas, including new tools for radiation treatments of cancer patients and the assessment of health risks to astronauts. The K500 was the first cyclotron to use superconducting magnets, and the K1200 is the highest-energy continuous beam accelerator in the world. Through the recently completed Coupled Cyclotron Facility (CCF), heavy ions are accelerated by the K500 and then injected into the K1200, enabling the production of rare unstable isotopes at much higher intensities and opening a new window on the cosmos.

Scientists at the NSCL work at the forefront of rare isotope research. They make and study atomic nuclei that cannot be found on earth and perform experimental research using beams of unstable isotopes to extend our knowledge of new types of nuclei, many of which are important to an understanding of stellar processes. Research activities include a broad program in nuclear astrophysics studies, the studies of nuclei far from stability using radioactive ion beams, and studies of the nuclear equation of state. In addition, research is carried out in accelerator physics.

NSCL supports and enhances doctorate level graduate education and post-doctoral research experience. Approximately 10 percent of all doctorates granted in nuclear physics in the United States are based on research at the NSCL. In addition, the site provides research experiences for undergraduate students, as well as training for K-12 teachers.

NSCL occasionally enters into license agreements with industry for cyclotron technology or nuclear electronics. A specific license agreement with Accel Corp. exists for compact cyclotrons based on superconducting technology.

An experimental program using the coupled cyclotron facility is now underway. The FY 2009 requested level of support is consistent with recommendations from an external 2006 science and operations review committee, and will enable near-optimal operations and research at this unique radioactive ion beam facility.

Facility Report:

<u>Management and Oversight:</u>

- NSF Structure: NSF has a Cooperative Agreement with Michigan State University (MSU) for operation of the NSCL. The Laboratory Director is the key named officer, who has the authority to appoint Associate Directors and to designate their responsibilities, notifying NSF of any such changes. NSF oversight is provided through annual site visits by the cognizant program officer of the Physics Division and other staff, accompanied by external experts.

- External Structure: The NSCL is managed by the Laboratory Director and three Associate Directors: one for Nuclear Science, one for Accelerator Research, and one for Operations. The NSCL research program is guided by a Program Advisory Committee consisting of external experts as well as an in-house expert, and includes the chairperson of the full NSCL User Group. The procedure for users includes writing and submitting proposals to the NSCL Director and oral presentations. There are two opportunities for proposal submission each year. Approximately 5,000 beam hours for experiments are provided each year. There is generally at least a one-year backlog for experiments.

- Reviews:
  - Latest Review: Science and operations review in FY 2006 prior to the renewal of the award beginning in FY 2007.
  - Next Review: Following the extensive review in FY 2006 prior to the renewal of the Cooperative Agreement, annual reviews are planned for FY2008 (to consider the first year of operations) and each year thereafter. The review topics include, but are not limited to science and operations (including management), with emphasis (and choice of external experts) to be determined

<u>Renewal/Recompetition/Termination</u>:

The NSCL is funded through a cooperative agreement that was renewed in FY 2007 and that will expire in FY 2011. NSF anticipates that MSU will submit a renewal proposal in FY 2011. NSF will decide at that time whether to recompete the award, or whether to proceed with merit review of the proposal. Funding for FY2012 and beyond will be determined by the outcome of that process.

Network for Engineering Earthquake Simulation $23,020,000

The FY 2009 Budget Request for the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) is $23.02 million, an increase of $850,000, or 3.8 percent, over the FY 2008 Estimate of $22.17 million.

Network for Earthquake Engineering Simulation
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Network for Earthquake Engineering Simulation	$20.74	$22.17	$23.02	$0.85	3.8%

NEES is a national, networked simulation resource of 15 advanced, geographically distributed, shared use earthquake engineering research experimental facilities with telepresence capabilities. NEES provides a national infrastructure to advance earthquake engineering research and education through collaborative and integrated experimentation, computation, theory, databases, and model-based simulation to improve the seismic design and performance of U.S. civil infrastructure systems. Experimental facilities include shake tables, geotechnical centrifuges, a tsunami wave basin, large-scale laboratory experimentation systems, and mobile and permanently installed field equipment. NEES facilities are located at academic institutions (or at off-campus field sites) throughout the U.S., networked together through a high performance Internet2 cyberinfrastructure system. NEES completed construction on September 30, 2004, and opened for user research and education projects on October 1, 2004. NEES is currently operated by the non-profit corporation NEES Consortium, Inc. (NEESinc), headquartered in Davis, California. Through an initial five-year cooperative agreement with NSF (FY 2005 – FY 2009), NEESinc operates the 15 experimental facilities and the NEES cyberinfrastructure center; coordinates education, outreach, and training; and develops national and international partnerships.

Total Obligations for NEES
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$20.74	$22.17	$23.02	$23.57	$23.57	$23.60	$24.19	$24.19

NEES' broad-based national research facilities and cyberinfrastructure enables new discovery and knowledge through capabilities to test more comprehensive, complete, and accurate models of how civil infrastructure systems respond to earthquake loading. This enables the design of new methodologies, modeling techniques, and technologies for earthquake hazard mitigation. NEES engages students in earthquake engineering discovery through on-site use of experimental facilities, telepresence technology, archival experimental and analytical data, and computational resources with the aim of integrating research and education. NEESinc has developed an education, outreach, and training strategic plan to develop a broad spectrum of education and human resource development activities with special emphasis on non-traditional users and underrepresented groups.

Through the Congressionally mandated National Earthquake Hazards Reduction Program (NEHRP), the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), the U.S. Geological Survey (USGS), and the NSF support research related to earthquake hazard mitigation. Connections to industry include private engineering consultants and engineering firms engaging in NEES research or using data and models developed through NEES. NEES is leveraging and complementing its capabilities through connections and collaborations with large testing facilities at foreign earthquake-related centers, laboratories, and institutions. NSF and NEESinc have recently developed partnerships to utilize the NEES infrastructure with the 3-D Full-Scale Earthquake Testing Shake Table Facility (E-Defense), built by the Japanese National Research Institute for Earth Science and Disaster Prevention (NIED) and operational in 2005. To facilitate NEES/E-Defense collaboration, in August 2005, NEESinc and NIED signed a Memorandum of Understanding (MOU), and in September 2005, NSF and the Japanese Ministry of Education, Culture, Sports, Science, and Technology signed a Memorandum Concerning Cooperation in the Area of Disaster Prevention Research. In March 2007, researchers from 22 countries convened in Ispra, Italy, for the second World Forum to discuss sharing expertise and coordination in earthquake engineering testing and cyberinfrastructure. NSF is also working with New Zealand, through the University of Aukland, to develop collaborative research in earthquake engineering.

The seven-story, 275-ton reinforced concrete structure tested on the University of California, San Diego NEES shake table demonstrated a less costly seismic design method for residential structures in southern California. *Credit: Professor Jose estrepo, Department of Structural Engineering, UCSD*

Along with direct operations and maintenance support for NEES, NSF provides support for research conducted at NEES experimental facilities through ongoing research and education programs. The NEES cyberinfrastructure also provides a platform for the earthquake engineering community as well as other communities to develop new tools for shared cyberinfrastructure. In addition, NSF has initiated grand challenge, small group, individual investigator, payload, and simulation development research projects that utilize the NEES experimental facilities, data, and computational resources to comprehensively address major research questions in earthquake engineering and seismic hazard mitigation. The annual support for such activities, funded through annual program solicitations and through unsolicited proposals, is estimated to be $12.0 million. These awards support basic research in multi-hazard engineering involving experimental and theoretical simulations at the NEES facilities, addressing important challenges in earthquake and tsunami engineering research.

Facility Report:

<u>Management and oversight:</u>

- NSF structure: NSF provides oversight to NEES operations through a cooperative agreement with NEES Consortium, Inc. NEES operations are reviewed through annual site visits. The NSF program manager for NEES is located in CMMI. The Budget, Finance and Award Management Deputy Director for Large Facility Projects provides advice and assistance.

- External structure: NEES Consortium, Inc., located in Davis, CA, operates the 15 experimental facilities and the NEES cyberinfrastructure center; coordinates education, outreach, and training; and develops national and international partnerships. As a non-profit corporation, NEESinc. operates under its own governance structure and is overseen by a Board of Directors elected from its membership in accordance with its by-laws. Day-to-day operations of NEESinc. are overseen by its headquarters staff led by an Executive Director. Each of the 15 experimental facilities has an on-site director responsible for local day-to-day equipment management, operations, and interface with NEESinc., other NEES facilities, users, and the NEES cyberinfrastructure center for network coordination. The NEES cyberinfrastructure center maintains the telepresence, data, collaborative, simulation, and other related services for the entire NEES network.

- Reviews:
  - Management reviews: NSF BFA Business Systems Review – May 2006
  - Mid-award reviews NSF Annual Review - June 2005, April 2006, and July 2007
  - Upcoming reviews: NSF Annual Review/Renewal/Recompetition Review, July 2008

Renewal/Recompetition/Termination:

NEESinc operates under a five-year cooperative agreement, with annual funding based upon satisfactory progress and availability of funding; renewal review conducted in year four (July 2008) to determine if renewal beyond the initial five-year period is warranted.

Polar Facilities And Logistics **$353,020,000**

The FY 2009 Budget Request for Polar Facilities and Logistics is $353.02 million, an increase of $29.48, or 9.1 percent, over the FY 2008 Estimate of $323.54 million.

Polar Facilities and Logistics
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Polar Facilities	$219.20	$217.84	$241.50	$23.66	10.9%
Polar Logistics	$103.94	$105.70	$111.52	$5.82	5.5%
Total, Polar Facilities and Logistics	$323.14	$323.54	$353.02	$29.48	9.1%

Polar Facilities:

The Operations and Science Support program within the Division of Antarctic Infrastructure and Logistics in the Office of Polar Programs (OPP) provides support for all U.S. research conducted in Antarctica, including that funded by U.S. mission agencies, for year-round work at three U.S. stations, two research ships, and a variety of remote field camps. All life support is provided by NSF, including transportation, facilities, communications, utilities (water and power), and health and safety infrastructure. The U.S. Antarctic Program (USAP) also provides environmental stewardship and maintains the U.S. presence in Antarctica in accordance with U.S. policy.

Total Obligations for Polar Facilities
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Antarctic Infrastructure & Logistics	$166.24	$160.84	$187.50	$192.38	$197.38	$202.51	$207.77	$213.18
U.S. Coast Guard Icebreaker Support	$52.96	$57.00	$54.00	$54.00	$54.00	$54.00	$54.00	$54.00
Total, Polar Facilities	$219.20	$217.84	$241.50	$246.38	$251.38	$256.51	$261.77	$267.18

OPP contracts with a prime contractor for science support, operations, and maintenance of the Antarctic stations and related infrastructure in New Zealand and Chile, and leasing of research vessels. The contractor is selected through a competitive bidding process. Rotary- and fixed-wing aircraft used in support of research are provided through competitively awarded contracts. Other agencies and contractors provide technical support in areas of expertise such as engineering, construction, and communications.

Helicopters provide support to field parties in the McMurdo Dry Valleys in southern Victoria Land and at remote field camps. *Credit: Kristan Hutchison. RPSC.*

Facility Report:

Management and Oversight:

- NSF Structure: OPP has overall management responsibility for Operations and Science Support. Since FY 2006, NSF has also funded the operation and maintenance of the U.S. Coast Guard's (USCG) three polar icebreakers, the Polar Star, the Healy, and the Polar Sea. Beginning in FY 2009, it has been decided that NSF funds operation and maintenance for only the Polar Sea and the Healy because NSF does not envision current or future use of the Polar Star in support of its mission. The agencies cooperate under a Memorandum of Agreement that includes guidance for planning and scheduling. It sets forth the terms and conditions for reimbursement to the USCG by NSF. NSF and the USCG work together to formulate operations and maintenance plans and associated funding requirements. NSF is responsible for ascertaining the needs of other federal agencies and for securing USCG program plans for accommodating them on a reimbursable funding basis.

- External Structure: The current Antarctic support contract was recompeted and awarded to Raytheon Polar Services Company (RPSC) in FY 2000. There are many separate subcontractors for supplies and technical services.

- Reviews: OPP evaluates the performance of RPSC every year via a Performance Evaluation Committee and an Award Fee Board that includes representatives from OPP and the Office of Budget, Finance, and Award Management (BFA). The Operations and Science Support program in the Division of Antarctic Infrastructure and Logistics also provides oversight of the South Pole Station Modernization (SPSM) project, an activity funded out of the Major Research Equipment and Facilities Construction (MREFC) account since FY 1998. In addition, OPP's performance is reviewed externally by Committees of Visitors and the OPP Advisory Committee (OPP AC).

Current Status:

- All facilities (stations, research vessels, and field camps) are currently operating normally. The relatively poor condition of the USCG polar icebreakers, the Polar Star and the Polar Sea, due to their age and the uncertainty regarding their future availability prompted OPP and the OPP AC to identify and study options for reducing demands on the ship-based logistics system. OPP is implementing several projects as contingencies against a possible failure of that system.

Renewal/Recompetition/Termination:

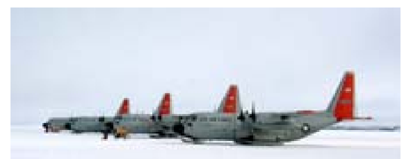
U.S. policy directs NSF to maintain an active and influential presence in Antarctica, including year-round occupation of South Pole Station and two coastal stations. Therefore, NSF will not terminate support for the facilities themselves, such as McMurdo Station or South Pole Station. However, the research emphases at the three stations changes as the scientific forefronts addressed there evolve with time. The current Antarctic support contract was recompeted and awarded to Raytheon Polar Services Company (RPSC) in FY 2000. After a five-month phase-in period, RPSC assumed responsibility for operations in March 2000. The contract's ten-year performance period is segregated into a five-year initial period and a five-year option period. NSF exercised its option to extend the performance period through 2010.

Polar Logistics:

Polar Logistics consists of two activities: the U.S. Antarctic Logistical Support Activities program within the Division of Antarctic Infrastructure and Logistics, and the Research Support and Logistics program within the Arctic Sciences Division.

Total Obligations for Polar Logistics
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
U.S. Antarctic Logistical Support	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52
Research Support and Logistics	$36.42	$38.18	$44.00	$45.32	$46.68	$48.08	$49.52	$51.01
Total, Polar Logistics	$103.94	$105.70	$111.52	$112.84	$114.20	$115.60	$117.04	$118.53



The U.S. Antarctic Logistical Support Activities program funds support provided by the U.S. Department of Defense (DoD). The DoD operates as a primary logistical support provider on a cost-reimbursable basis. Major funding elements of DoD support include: military personnel, LC-130 flight operations, maintenance, and facilities support of the 109th Airlift Wing (AW) of the New York Air National Guard in Scotia, New York and Antarctica; transportation and training of military personnel supporting the U.S. Antarctic Program; support for air traffic control, weather forecasting, and ground electronic equipment maintenance; the charter of Air Mobility Command airlift and Military Sealift Command ships for the re-supply of McMurdo Station; bulk fuel purchased from the Defense Logistics Agency; and reimbursement for use of DoD satellites for communications.

The Research Support and Logistics program in the Arctic Sciences Division is driven by and responds to science supported by the Division. Funding is provided directly to grantees or to key organizations that provide or manage Arctic research support and logistics. The current contract with CH2M HILL (previously, VECO USA) to provide research support and logistics services for NSF-sponsored activities in the Arctic was recompeted and awarded in January 2005. The contract has an initial term of four years and the possibility of three one-year extensions exercised on the basis of performance. Additional major support components include: access to U.S. Coast Guard and other icebreakers, University-National Oceanographic Laboratory (UNOLS) vessels and coastal boats; access to fixed and rotary-wing airlift support; upgrades at Toolik Field Station, University of Alaska, Fairbanks' field station for ecological research on Alaska's North Slope; safety training for field researchers and funding for field safety experts; global satellite telephones for emergency response and improved logistics coordination; and development of a network of strategically placed U.S. Long-Term Ecological Research observatories linked to similar efforts in Europe and Canada.

Facility Report:

Management and Oversight

- NSF Structure: OPP has overall management responsibility for U.S. Antarctic Logistical Support Activities and Arctic Research Support & Logistics. DoD operates as a primary logistical support provider on a cost-reimbursable basis. The agencies cooperate under a Memorandum of Agreement that includes guidance for planning and scheduling and sets forth the terms and conditions for reimbursement to DoD by NSF.

- External Structure: There are many separate subcontractors for supplies and technical services.

- Reviews: OPP's performance is externally reviewed by Committees of Visitors and the OPP AC.

Current Status:

- All facilities (stations, research vessels, and field camps) are currently operating as normal.

Renewal/Recompetition/Termination:

U.S. policy directs NSF to maintain an active and influential presence in Antarctica, including year-round occupation of South Pole Station and two coastal stations. Therefore, NSF will not terminate support for the facilities themselves, such as McMurdo Station or South Pole Station. However, the research emphases at the three stations changes as the scientific forefronts addressed there evolve with time. Support contracts are recompeted as noted earlier.

National Astronomy and Ionosphere Center $11,500,000

The FY 2009 Budget Request for the National Astronomy and Ionosphere Center (NAIC) is $11.50 million, a decrease of $650,000, or 5.3 percent below the FY 2008 Estimate of $12.15 million.

National Astronomy and Ionosphere Center
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
National Astronomy and Ionosphere Center	$10.46	$12.15	$11.40	-$0.75	-6.2%

The NAIC is a visitor-oriented national research center, supported by NSF and focusing on radio and radar astronomy and atmospheric sciences. NAIC is a Federally Funded Research and Development Center (FFRDC) whose principal observing facility is the world's largest radio/radar telescope, a 305 meter diameter reflector constructed within a karst depression in western Puerto Rico near the town of Arecibo. The facility itself is called the Arecibo Observatory. The NAIC is operated by Cornell University for NSF under a cooperative agreement. NAIC provides telescope users with a wide range of research and observing instrumentation and serves over 250 users annually. The center has a permanent staff of scientists, engineers, and technicians who are available to help visiting investigators with their observation programs.

Total Obligations for NAIC
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance (AST)	10.46	10.45	9.60	8.00	4.00	4.00	4.00	4.00
Operations and Maintenace (ATM)	-	1.70	1.80	2.05	2.50	2.50	2.50	2.50
Total, NAIC	$10.46	$12.15	$11.40	$10.05	$6.50	$6.50	$6.50	$6.50

NAIC is jointly supported by the Division of Astronomy (AST/MPS) and the Division of Atmospheric Sciences (AST/GEO). The Astronomy Senior Review recommended an emphasis on survey work and a reduction in AST funding to $8.0 million for the NAIC by 2010. In response, the managing organization, Cornell University, has modified the operating mode for astronomy observations and limited the observing time for astronomy projects. These changes also resulted in a reduction in force of 30 Full-Time Equivalents (FTEs) in FY 2007. In addition, a substantial reduction in the availability of the S-band planetary radar system is anticipated in FY 2008. The FY 2009 Budget Request reflects a planned ramp down to meet the Senior Review recommendation of $8.0 million of AST support by FY 2010. The 900-ton suspended receiver support platform was sandblasted and repainted during the 2007. The $4.0 million project was required to address issues of safety, and was funded by AST and MPS's Office of Multidisciplinary Activities.

The NAIC was founded to advance the study of basic research in radio astronomy, solar system radar astronomy, and ionospheric physics. NAIC's primary education goal is to support and enhance the education of graduate and undergraduate student researchers. Arecibo hosts a Research Experiences for Undergraduates (REU) site. At Arecibo, graduate students receive training through use of the facility for Ph.D. research. NAIC also sponsors a major outreach program in Puerto Rico via a modern Visitor's

Center, a new Learning Center, and summer workshops for K-12 teachers. In addition NAIC holds, in collaboration with the National Radio Astronomy Observatory (NRAO), a summer school on single-dish radio astronomy techniques.

An image of the Arececibo Radio Telescope in Puerto Rico. The gregorian dome and its suspension structure are visible over the main deflector below. *Credit: Arecibo Observatory/NSF*

NAIC currently has partnerships with NRAO, Pennsylvania State University and other universities, and the Angel Ramos Foundation of Puerto Rico (a private organization).

A peer-review telescope allocation committee provides merit-based telescope time but no financial support. NSF does not provide awards targeted specifically for use of Arecibo. Many users are supported through NSF or NASA grants to pursue scientific programs that require use of NAIC.

Facility Report:

Management and Oversight:

- NSF Structure: Ongoing oversight and assessment is by an assigned NSF program director in AST and in consultation with community representatives. The program director makes use of detailed annual program plans, long range plans, quarterly reports (technical and financial) and annual reports that are submitted to NSF by Cornell as well as attending Cornell governance committees. AST program managers work closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support, the Office of General Counsel, and the Large Facilities Project Office to address issues as they arise.

- External Structure: Management is via a cooperative agreement with Cornell University. Cornell provides management and oversight through its own advisory committees and visiting committees. The NAIC Director is resident at Cornell, and reports to the Vice Provost for Research in Physical Sciences and Engineering. The Arecibo Observatory Site Director reports to the NAIC Director.

- Reviews: Management reviews by external review panels are held midway into each 5-year cooperative agreement. The last management review was in March 2007. NAIC underwent a Business Systems Review by the Office of Budget, Finance, and Award Management in FY 2005. In addition, in response to recommendations from the Senior Review, AST is carrying out a review of administrative and operational costs at all its facilities.

Renewal/Recompetition/Termination:

- The current cooperative agreement with Cornell for the management of Arecibo is in effect through March 31, 2010.

- The Senior Review recommended a further reduction in AST funding to $4.0 million per year beginning in 2011. Cornell is in the process of developing a business plan for 2011 and beyond, seeking other sources of support and examining alternative modes of operation that may reduce operating costs. AST is contracting a study that will provide an estimate of costs for various options, from mothballing to complete removal of the telescope and buildings and return of the site to a natural state. The costs of these options, and the viability of the business plan for continued operation, must be known by the spring of 2009 in order to make a decision about the future of Arecibo that would support development of the FY 2011 Budget Request.

National Center for Atmospheric Research (NCAR) **$95,870,000**

The FY 2009 Budget Request for the National Center for Atmospheric Research is $95.87 million, an increase of $8.33 million, or 9.5 percent, over the FY 2008 Estimate of $87.54 million.

National Center for Atmospheric Research
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
National Center for Atmospheric Research	$85.12	$87.54	$95.87	$8.33	9.5%

The National Center for Atmospheric Research is a federally funded research and development center (FFRDC) serving a broad research community, including atmospheric scientists and researchers in complementary areas of the environmental and geosciences. Facilities available to university, NCAR, and other researchers include world-class supercomputing services, research aircraft, which can be equipped with sensors to measure dynamic physical and chemical states of atmospheric phenomena at local, regional, and global scales, airborne and portable ground-based radar systems, atmospheric sounding, and other surface sensing systems are available for atmospheric research. NCAR operates several facilities of the High Altitude Observatory (HAO) that are dedicated to the study of the Sun, solar phenomena, space weather, and the responses of the upper atmosphere to the Sun's output. As an NSF sponsored facility, NCAR is committed to the dissemination of newly discovered knowledge in all the above areas.

NCAR's Mesa Laboratory, designed by architect I.M. Pei, in Boulder, CO. *Credit: NSF*

Total Obligations for NCAR
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$85.12	$87.54	$95.87	$98.27	$100.72	$103.24	$105.82	$108.47

In FY 2009, increased investments at NCAR will focus on issues of societal importance in the areas of atmospheric chemistry, climate, cloud physics and storms, weather hazards to aviation, and interactions between the Sun and Earth. In all of these areas, NCAR scientists will work with their university colleagues to look closely at the role of humans in both creating climate change and responding to severe weather occurrences. Example investments are an increased emphasis on preparing input for the next Intergovernmental Panel on Climate Change (IPCC) assessment and research into significantly enhancing our ability to understand and predict changes in hurricane intensity. In addition, investment in the refurbishment of the NSF-owned infrastructure is planned.

As an internationally-recognized center of excellence, NCAR operates scientific research programs that include the following areas: studies of large-scale atmospheric and ocean dynamics that contribute to an understanding of the past and present climate processes and global climate change; global and regional atmospheric chemistry, including atmospheric connections to geochemical and biogeochemical cycles;

the variable nature of the Sun and the physics of the corona and their interaction with the Earth's magnetic field; the physics of clouds, thunderstorms, precipitation formation, and their interactions and effects on larger-scale weather; and the examination of human society's impact on and response to global environmental change. In addition, NCAR further supports the scientific community by providing fellowships, internships, workshops, and colloquia for students and visiting scientists, and disseminates knowledge of the geosciences to the general public, K-12 schools, teachers and students, undergraduate and graduate institutions, postdoctoral and career scientists and researchers, as well as to policy and decision makers. Professional training courses, innovative and award-winning science education websites, as well as the directed activities of NCAR's Office of Education and Outreach are further examples of how NSF's goal of integrating research and education is attained through NCAR activities.

Research collaborations among NCAR staff and university colleagues are integral to its success as an institution, and serve as a focus and meeting point for the broader atmospheric and related sciences community. Further, NCAR works to develop new collaborations and partnerships with the private sector through directed research and technology transfer. These activities span improved capabilities for detecting, warning, and forecasting mesoscale weather phenomena of economic and social importance to the private and public sectors to longer term economic consideration of climate change issues.

NCAR will continue to support its broad science and education programs and continue its support of facilities that serve the atmospheric community, specifically supercomputing and observing facilities. These are detailed in the NCAR Program Plan.

The NCAR strategic plan, "NCAR as Integrator, Innovator and Community Builder," was completed in FY 2006. The plan sets outs the mission, core values and strategic goals that guide NCAR science. In working towards these goals, NCAR will seek to support the scientific community in explaining how the Earth system functions and accurately predicting how it is likely to evolve, providing robust, accessible, and well-integrated information services and tools for research, analysis, and education. NCAR also prepares an annual report (www.nar.ucar.edu/), which provides a summary of the full life-cycle of the research, facilities, and educational activities that have taken place in FY 2006.

Facility Report:

Management and Oversight:

- NSF Structure: NSF's Division of Atmospheric Sciences (in GEO) along with the Division of Acquisitions and Cooperative Support (DACS), provide oversight of NCAR and the cooperative agreement with the University Corporation for Atmospheric Research (UCAR) for its management.

- External Structure: NCAR is managed by the University Corporation for Atmospheric Research (UCAR), a university-governed and university-serving organization comprising 71 Ph.D. granting academic institutions. UCAR works in partnership with NSF, the university community, and its other research sponsors such as NASA, NOAA, DOE, DOD, EPA, and the FAA wherever such research collaboration enhances NCAR's basic NSF-supported research goals or facilities missions

- Reviews:
  - Management review: March, 2006.

Renewal/Recompetition/Termination:

The cooperative agreement for the management of NCAR is currently being competed. The next agreement will be for the five years beginning in FY 2009. Proposals will be subject to NSF's standard merit review procedures, with expert reviewers who are preeminent researchers and managers.

National Optical Astronomy Observatory and National Solar Observatory **$41,830,000**

The FY 2009 Budget Request for the National Optical Astronomy Observatory (NOAO) and the National Solar Observatory (NSO) is $41.83 million, an increase of $3.28 million, or 8.5 percent, above the FY 2008 Estimate of $38.55 million.

The National Optical Astronomy Observatory and the National Solar Observatory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
National Optical Astronomy Observatory and National Solar Observatory	$34.55	$34.55	$36.83	$2.28	6.6%
Telescope System Instrumentation Program	$4.00	$4.00	$5.00	$1.00	25.0%
Adaptive Optics Development Program	$0.73	-	-	-	-
Total	$39.28	$38.55	$41.83	$3.28	8.5%

NOAO was established in 1982 by uniting the operations of the Kitt Peak National Observatory (KPNO) in Arizona and the Cerro Tololo Inter-American Observatory (CTIO) in Chile. NOAO is a Federally Funded Research and Development Center (FFRDC) for research in ground-based, nighttime, optical and infrared astronomy. NOAO also is the gateway for the U.S. astronomical community to the International Gemini Observatory. NSO operates facilities in New Mexico and Arizona as well as a coordinated worldwide network of six telescopes (GONG++) specifically designed to study solar oscillations. NSO makes the world's largest collection of optical and infrared solar telescopes and auxiliary instrumentation available to qualified scientists for observation of the solar photosphere, chromosphere, and corona. NSO also provides routine, synoptic solar data used by many researchers and other agencies. As national facilities, NOAO and NSO telescopes are open to all astronomers regardless of institutional affiliation on the basis of peer-reviewed observing proposals. They serve over 1,000 scientists annually.

Total Obligations for NOAO/NSO
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$34.55	$34.55	$36.83	$37.93	$39.07	$40.24	$41.45	$42.70
Telescope System Instrumentation Program	$4.00	$4.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00
Adaptive Optics Development Program	$0.73	-	-	-	-	-	-	-
Total, NOAO/NSO	$39.28	$38.55	$41.83	$42.93	$44.07	$45.24	$46.45	$47.70

The FY 2009 Request for base operations for NOAO and NSO is $36.83 million, an increase of $2.28 million over the FY 2008 Estimate. This reflects the transfer of the Advanced Technology Solar Telescope (ATST) engineering design funding of $2.5 million to the Major Research Equipment and Facilities Construction (MREFC) account as well as an increase that will support year two of the facilities' response to the recommendations of the AST Senior Review, which included (i) reinvestment in the infrastructure at KPNO and CTIO and (ii) reductions in several targeted programs. In FY 2009 NOAO plans to begin a multi-year effort to introduce new capabilities to the U.S. community through investment in new capabilities at KPNO and CTIO and through additional access to non-federal observatories. NOAO manages the national community involvement in the development of potential future infrastructure projects such as the Giant Segmented Mirror Telescope and the Large Synoptic Survey Telescope, both of which are high priority recommendations of the 2000 Decadal Survey conducted by the National Research Council's Astronomy and Astrophysics Survey Committee. NOAO also administers the Telescope System Instrumentation Program (TSIP), funded by NSF, which supports the development and fabrication of instrumentation at private observatories in return for competitively reviewed observing time for the general community. TSIP funding increases by $1.0 million in the FY 2009 Request. NSO is leading the community in design and development of ATST. More information on this project can be found in the MREFC chapter.

The Cerro Tololo Inter-American Observatory 4-meter telescope dome. *Credit: M. Urzua Zuniga/Gemini Observatory.*

NOAO and NSO support basic research in astronomy and solar physics by providing access to forefront, ground-based, observing facilities to the nation's astronomers and solar physicists; by acquiring and archiving astronomical and solar data; by leading development of new astronomical facilities and techniques; by conducting scientific research; and by implementing partnerships with universities, non-federal observatories, and industry to achieve scientific objectives of benefit to the entire nation. Both observatories support U.S. goals in education by promoting public understanding and support of science and by providing education and training programs at all levels. Typically, twenty-five percent of the doctorates awarded annually in astronomy involve use of NOAO/NSO facilities by graduate students. The observatories introduce undergraduate students to scientific research by providing these students stimulating environments where they are exposed to basic astronomical research and related technologies through NSF's Research Experiences for Undergraduate Students (REU) program. NOAO and NSO have diverse education programs, visitor centers, and Web-based information portals.

Thirty-three U.S. member institutions and seven international affiliate members comprise the member institutions of the Association of Universities for Research in Astronomy (AURA), Inc., the management organization for NOAO and NSO. Other partners include the U.S. Air Force Office of Scientific Research, NASA, and industrial vendors. A large number of U.S. universities support their own astronomical facilities at KPNO and CTIO. Development of new telescopes, instrumentation, and sensor techniques is done in partnership with relevant industry through subawards to aerospace, optical fabrication, and information technology companies.

For all NOAO and NSO telescopes, peer-review telescope allocation committees provide merit-based telescope time but no financial support. NSF does not provide awards targeted specifically for use of NOAO and NSO. Many users are supported through NSF or NASA grants to pursue scientific programs that require use of NOAO and NSO.

Facility Report:

<u>Management and Oversight:</u>

- NSF Structure: An NSF program director in the Division of Astronomy (AST) in consultation with community representatives provides ongoing oversight and assessment. The program director makes use of detailed annual program plans, long range plans, quarterly reports (technical and financial) and annual reports that are submitted to NSF by NOAO and NSO as well as attending the AURA governance committees. AST program managers work closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support, the Office of General Counsel, and the Large Facilities Project Office to address issues as they arise.

- External Structure: AURA manages the observatories through community-based Observatory Councils, Users' Committees, and Visiting Committees. Separate directors for NOAO and NSO report to the president of AURA.

- Reviews: In addition to reviews held mid-way through all cooperative agreements, NSF conducts periodic reviews of AURA management as needed by external committees. In addition, in response to recommendations from the Senior Review, AST is carrying out a review of administrative and operational costs at all its facilities.

<u>Renewal/Recompetition/Termination:</u>

A management review of AURA's performance was carried out in August 2006. In response to the favorable review, the National Science Board extended the current cooperative agreement with AURA for eighteen months, through March 31, 2009. The additional time permits NSF and AURA to incorporate the recommendations of the AST Senior Review into management of NOAO and NSO. A proposal from AURA for a new cooperative agreement for the period FY 2009 – 2013 will be reviewed in FY 2008.

National Radio Astronomy Observatory $61,560,000

The FY 2009 Budget Request for the National Radio Astronomy Observatory (NRAO) is $61.56 million, an increase of $8.82 million, or 16.7 percent, over the FY 2008 Estimate of $52.74 million.

The National Radio Astronomy Observatory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
National Radio Astronomy Observatory	$50.75	$52.74	$61.56	$8.82	16.7%

NRAO provides state-of-the-art radio telescope facilities for use by the scientific community. NRAO conceives, designs, builds, operates, and maintains radio telescopes used by scientists from around the world to study virtually all types of astronomical objects known, from planets and comets in our own Solar System to quasars and galaxies billions of light-years away. It is a Federally Funded Research and Development Center (FFRDC), which operates major radio telescopes in Green Bank, West Virginia, near Socorro, New Mexico, and at ten telescope array sites spanning the U.S. from the Virgin Islands to Hawaii. NRAO's headquarters are in Charlottesville, Virginia. NRAO is also the North American implementing organization for the international Atacama Large Millimeter Array (ALMA) project. These federally funded, ground-based observing facilities for radio astronomy are available to any qualified astronomer, regardless of affiliation or nationality, on the basis of scientific peer-reviewed proposals, and annually serve over 1,500 users worldwide.

Total Obligations for NRAO
(Dollars in Millions)

	FY 2007	FY 2008	FY 2009	ESTIMATES				
	Actual	Estimate	Request	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$41.20	$38.51	$43.61	$43.15	$43.24	$42.89	$44.33	$46.95
ALMA operations	$3.71	$8.22	$11.77	$17.57	$23.50	$30.65	$33.92	$36.41
Implementation of EVLA	$5.84	$6.01	$6.19	$6.38	$1.13	-	-	-
Total, NRAO	$50.75	$52.74	$61.56	$67.10	$67.86	$73.54	$78.25	$83.36

NRAO supports and advances basic research in the astronomical sciences, including understanding the geometry and the matter content of the universe, the formation of galaxies, stars and planets, and the nature of black holes. The primary education goal is to support the development of a scientifically and technically literate society through a comprehensive outreach program in which information about radio astronomy is made available to the public through the world-wide web and news media. Observational facilities are used by graduate students carrying out dissertation research and those on work experience programs and by undergraduate students participating in the Research Experiences for Undergraduates (REU) program. NRAO sites support visitor/education centers and conduct an active educational and public outreach program.

Numerous U.S. universities, NASA, foreign scientific and technical institutes, and industrial vendors are partners. The development of new telescopes, instrumentation, and sensor techniques is completed in partnership with relevant industries through competitive subawards to various large and small aerospace companies, radio antenna manufacturing firms, and specialized electronics and computer software companies.

A peer-review telescope committee allocates merit-based telescope time but provides no financial support. NSF does not provide individual investigator awards targeted specifically for use of NRAO facilities. Many users are supported through NSF or NASA grants to pursue scientific programs that require use of NRAO.

The Very Large Array (VLA) is undergoing an upgrade of its electronics and communications systems, referred to as Phase I of the Expanded Very Large Array (EVLA), to significantly enhance its capabilities. Work on EVLA began in FY 2001 and is scheduled to be completed in FY 2011. The project is on budget and schedule.

The Very Large Array (VLA) telescope is located about 80 kilometers west of Socorro, New Mexico. The VLA is composed of 27 individual antennas arranged in a "Y" pattern. In their closest configuration (about 1 kilometer wide), the VLA is able to image large portions of the sky. In its largest configuration (about 36 kilometers wide) the VLA is able to hone in on the fine details of astronomical objects. *Credit: NRAO/AUI and Kelly Gatlin, Patricia Smiley*

The NRAO is also engaged in construction of the international ALMA, which in FY 2009 will be entering the 8th year of its eleven year construction phase, funded through the MREFC account. NRAO is the U.S. implementing organization of the ALMA project. Early operations funding for ALMA began in FY 2005 and ramps up steeply in FY 2009. An Operations Plan and a proposal for North American operations were externally reviewed in FY 2007, and a funding profile through FY 2011 was authorized by the National Science Board in December 2007. The operations estimates for FY 2012 and beyond are based on current cost projections. Additional information on the ALMA project is available in the MREFC chapter.

The NRAO budget profile in FY 2011 and following years shows the implementation of the recommendation of the Astronomy Senior Review that operations support for the Very Long Baseline Array (VLBA) be reduced. Details of the budget profile in FY 2010 and beyond are subject to revision as a result of the outcome of cost reviews.

Facility Report:

Management and Oversight:

- NSF Structure: Ongoing oversight and assessment is by an assigned NSF program director in AST and in consultation with community representatives. The program director makes use of detailed annual program plans, long range plans, quarterly reports (technical and financial) and annual reports that are submitted to NSF by NRAO as well as attending the governance committees of the managing organization, Associated Universities, Inc (AUI), in carrying out oversight responsibilities. AST program managers work closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support, the Office of General Counsel, and the Large Facilities Project Office to address issues as they arise.

- External Structure: Management is through a cooperative agreement with AUI. AUI manages the observatory through community-based oversight and users' committees. The NRAO director reports to the president of AUI.

- Reviews: In addition to reviews held mid-way through all cooperative agreements, NSF conducts periodic reviews of AUI/NRAO management by external committees on an ad hoc basis. In addition, in response to recommendations from the Senior Review, AST is carrying out a review of administrative and operational costs at all its facilities in 2008.

<u>Renewal/Recompetition/Termination:</u>

The present cooperative agreement was extended to the end of FY 2009 with approval by the National Science Board in December 2005. A management review of AUI was carried out in early FY 2007. On the basis of this and reviews of ALMA operations, AUI is preparing a renewal proposal for the operation and management of NRAO for the period FY 2009-2013.

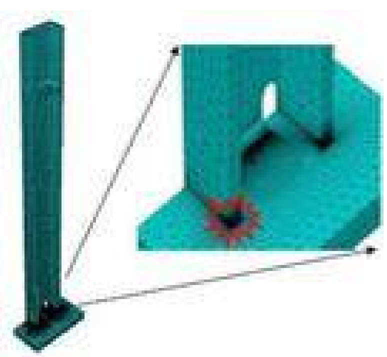
RECENT RESEARCH HIGHLIGHTS

An Air Force C-17 provides supplies to the South Pole Station. *Credit: Photo Courtesy of the United States Antarctic Program.*

► **Air Force C-17 Air Drop at South Pole Station:** During the 2006/2007 season the first operational C-17 airdrop was successfully accomplished over South Pole station. The use of C-17s provides significant additional logistics capabilities for the United States Antarctic Program and insures an emergency capability to deliver supplies during the austral winter. This option can also be applied during the austral summer to deliver up to 90,000 pounds of material to assist in the establishment or re-supply of inland remote science support facilities.

► **A Comprehensive 3-D Digital Atlas Database of the Mouse Brain:** The use of genetically altered mice has revolutionized biomedical research and genetics as numerous genetic diseases can be studied and better understood with a "mouse model" of the disease. But before the effects of the mutations can be fully understood, a benchmark study of a normal mouse was needed. Researchers for the National High Magnetic Field Laboratory working at Brookhaven National Laboratory and the University of Florida successfully used microimaging at 750 MHz in the Advanced Magnetic Resonance Imaging Spectroscopy to make a comprehensive 3-D digital mouse brain atlas of the standard lab mouse. This work was recognized by a cover article in the prestigious American Journal Neuroradiology.

This work was recognized by a cover article in the prestigious American Journal Neuroradiology. *Credit: NHMFL.*



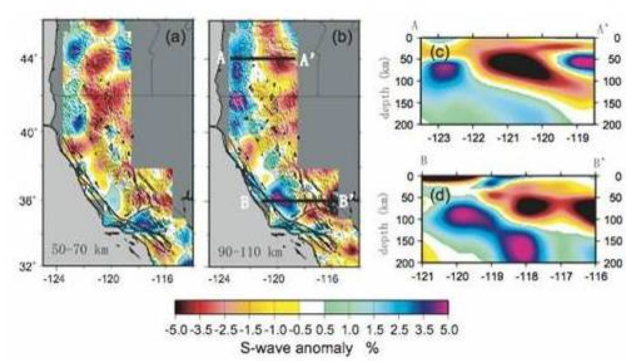
Computer model of damage sustained by a steel column in an earthquake resistant building during testing at NEES facilities. *Credit: Amit Kanvinde, University of California-Davis.*

► **Predicting Earthquake-Induced Fractures in Steel Structures:** Much of the nation's infrastructure consists of steel structures that can fracture during earthquakes. For the first time, researchers using the George E. Brown Jr. Network for Earthquake Engineering Simulation have developed computer models explaining how failure is linked to the growth and shrinkage of microscopic cavities in the steel. In the past, it was only possible to test steel structures experimentally and it wasn't feasible to test large structures. By combining testing and simulation, the researchers developed verified computer models that will allow engineers to design and construct structures that will better withstand earthquakes.

► **South Pole Telescope:** The largest telescope (10m) in Antarctica was successfully constructed and tested at the South Pole during the 100-day 2006/2007 summer season. The observations from this telescope will provide data for new insights to the answers that have been the focus of several national reports, including the 2000 Decadal Report on Astronomy and Astrophysics, the National Research Council's *Connecting Quarks with the Cosmos*, the Office of Science and Technology Policy report *Physics of the Universe*, and most recently the reports of the *Cosmic Microwave Background Task Force* and the *Dark Energy Task Force*.

South Pole telescope. *Credit: Photo courtesy United States Antarctic Program.*

► **Powerful Techniques to Discover Structure of Earthquakes:** Scientists have developed powerful new analytical methods to create images of structures within the earth's crust. Using data from NSF's EarthScope facility, previously considered to be useless "noise" in seismic records, innovative analysis revealed a wealth of seismic features. Earth scientists anticipate using this new technique to peer into the earth's crust and upper mantle across the conterminous U.S. and Alaska as the EarthScope transportable seismic array rolls across the continent over the next decade.

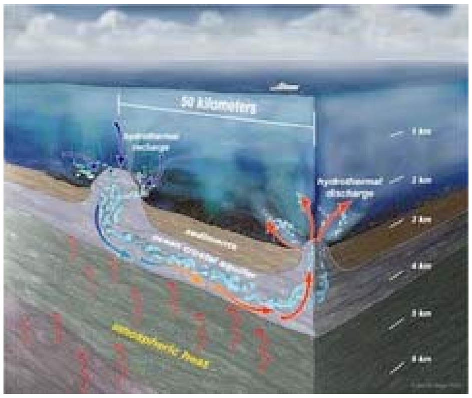


Example model slices from a joint inversion of earthquake and seismic noise. (a) and (b) horizontal slices in the upper mantle at about 60 km and 100 km depth, respectively. (c) and (d) vertical east-west oriented profiles across A-A' the Cascades in central Oregon and B-B' the Great Valley and southern Sierra Nevada Mountains in south-central California. *Credit: Yang, Ritzwoller, Moschetti and Forsyth (2006).*

► **Hilo Students Observe Comet Break-up with Gemini:** A new educational outreach program at NSF's Gemini Observatory in Hawaii is pairing local students with astronomers to do cutting edge astronomy with an 8-meter telescope. The first observations took place in the spring, when three students observed the disintegrating comet 73P/Schwassmann-Wachmann 3 in both visible and infrared light. The students observed the classic head and tail of the comet as well as multiple pieces of the comet's body breaking off. The students will work with the astronomers to do the final, more detailed reduction of the data and determine exactly how the nucleus is breaking apart. They will find out how warm the dust in the tail is and may even be able to tell how much dust is released in the disintegration.

Gemini's Head of Science, Dr. Jean-Rene Roy, looks on as Ken Oyadomari, Keane Nakatsu, Nick Higa, and Gemini astronomer Dr. Scott Fisher (foreground to background) collect comet data at the Gemini North control room in Hilo. *Credit: Gemini Observatory/AURA/NSF.*

► **The Ocean Below the Ocean:** The oceanic crust is the largest fractured water-bearing formation (aquifer) on Earth. The water within this aquifer transports enormous amounts of heat, nutrients, and dissolved minerals across vast distances, influencing volcanic activity and earthquakes, seafloor mineral formation, ocean circulation and currents, and supporting largely unexplored ecosystems that live in an "ocean" below the ocean. There is so much water circulating through the oceanic crust below the seafloor that the entire volume of the ocean is "recycled" about every 200,000-500,000 years. An international team of scientists and graduate students from the U.S.A, Japan, and Europe recently studied this vast aquifer system off the coast of Washington through the NSF-supported Integrated Ocean Drilling Program (IODP). Among results so far, scientists have found that a "hydrothermal siphon" is established, wherein seawater uses volcanic seamounts and permeable crustal rocks to bypass thick layers of impermeable sediment: Seawater is sucked in at one volcanic outcrop and is expelled at another. Thus, the 80,000 to 100,000 seamounts on the seafloor worldwide constitute a vast network of flow channels in the oceanic crust, allowing water, heat, chemicals, and microbiological materials to be exchanged between the ocean and the crust over vast areas. Aside from explaining many crucial processes on Earth, there is even the possibility that similar environments exist on other bodies in our solar system and may be important for harboring life outside of the Earth.

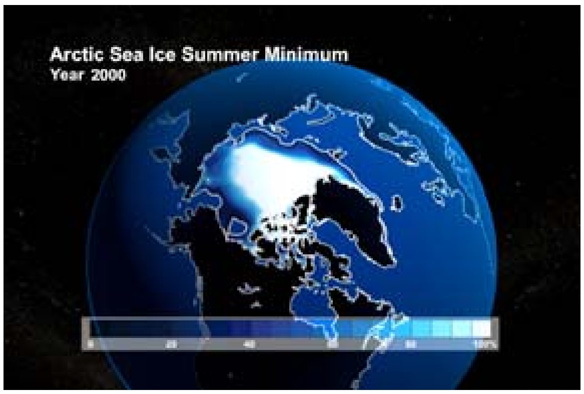


The siphon effect with circulating fluids entering the seafloor at one seamount and exiting from another after traversing the fractured and permeable ocean crust. *Credit: A. Fisher*.

► **Stellar Blast Teaches Astronomers New Lessons About Cosmic Explosions: A** powerful thermonuclear explosion on a dense white dwarf star last February gave astronomers their best look yet at the early stages of such explosions, called novae, and of bigger explosions, called supernovae, that are used to measure the expansion history of the Universe. Using the National Science Foundation's Very Long Baseline Array, the Very Large Array and other telescopes, scientists at the University of Manchester's Jodrell Bank Observatory in the United Kingdom saw structure in the blast earlier than in any other stellar explosion. They also saw evidence the explosion may be ejecting material in jets, an observation contrary to theoretical models that assume a spherical shell of ejected material. The researchers agree that their studies show that the explosion is more complex than scientists previously thought such blasts to be.

An artist's rendition of RS Ophiuchi, a symbiotic recurrent nova that went into outburst on 12 February 2006. *Credit: David A. Hardy. (www.astroart.org & PPARC).*

► **Abrupt Ice Retreat Could Produce Ice-Free Arctic Summers by 2040:** An ice-free Arctic could have major implications for weather and climate around the world. Once almost unthinkable, recent research shows that the retreat of Arctic sea ice is likely to rapidly accelerate. To analyze how global warming could affect the ice in coming decades, a team of NSF-supported scientists studied a series of computer simulations run on the Community Climate System Model, one of the world's leading tools for studying climate change. Having first tested the model to show that it closely matched observations of ice cover since 1870, the team simulated Arctic sea ice cover in the future. The results indicated that if greenhouse gases continue to build up in the atmosphere at the current rate, the Arctic's future ice cover will go through periods of relative stability followed by an abrupt retreat so rapid that the Arctic Ocean could become nearly devoid of ice during summertime as early as 2040.



This image, based on simulations produced by the Community Climate System Model, shows the approximate extent of Arctic sea ice in September. The model indicates that this late-summer ice could begin to retreat abruptly within several decades. (Illustrations ©UCAR.) *Credit: UCAR* .

By about 2040 (above), the Arctic may be nearly devoid of sea ice during the late summer unless greenhouse gas emissions are significantly curtailed. (Illustrations ©UCAR) *Credit: UCAR.*

NSF-WIDE INVESTMENTS

ADAPTIVE SYSTEMS TECHNOLOGY

Goal: To generate creative pathways and natural interfaces between human and physical systems that will revolutionize the development of novel anticipatory and adaptive systems.

Description and Scientific Rationale: Beneath the "skins" of modern machines, robots, or computational systems lies an electro-mechanical nervous system sporting a complex network of sensors, relays, wires, fiber optics, wireless communications, and other devices. The parallels and synergies between machine and human nervous and sensory systems are striking and are of great scientific and practical interest. The human brain, neural-sensory, and neural-muscular systems are, however, far more adaptive, anticipatory, resilient, and versatile than any electro-mechanical system, and our recent progress in probing their secrets has been potentially transformative. We are only just beginning to see the application of these new and transformational neuroscience discoveries to the development of engineered systems, especially at the human-machine interface. New applications, technologies, and products resulting from the convergence of human and physical systems have already demonstrated enormous economic potential (e.g., artificial retinas and cochlea, assistive devices, advanced diagnostic instrumentation and probes, electronic language translators, smart PDAs). Adaptive Systems Technology (AST), an environment that encourages and supports innovative research at the convergence of many disciplines, will better tap this enormous potential.

NSF will initiate and support this interdisciplinary environment and engage scientists and engineers from across the Nation. The nonlinear, dynamic design of complex engineered systems requires that a diversity of scientists and engineers work together on problems and concepts that extend from molecules to entire organisms. In the pursuit of a single, overarching challenge, each discipline contributes critical knowledge. Biology elucidates the evolution from simple to complex neural systems; physics and chemistry contribute the general principles of the neural organization and communications pathways; and mathematics, computer science, and cognitive science explain how the system computes. Learning and behavioral science provide insights into how the system learns and adapts to its environment, and engineering and computer science allow the design, analysis, and construction of systems that interface with or mimic the living neural network, to explore and expand human abilities. In developing applications from this research that are flexible, adaptive, and resilient, these pursuits must be integrated in ways such that the scientists and engineers mutually benefit from shared knowledge and experience, and inform each other's work through real-time collaboration. NSF has a long and successful history of supporting a broad segment of the science, engineering, and education communities in their achievement of interdisciplinary advances.

Most industrialized countries recognize that in a knowledge-based economy improved couplings at the human-machine interface can revolutionize human productivity and workforce development. AST is essential to advances in highly-innovative adaptive control systems, hybrid computer architectures, improved electronic PDAs, and computer-based, self-paced, learning and training tools. A series of recent NSF-supported workshops have highlighted this potential and noted that Europe and Asia are aggressively investing in this area of research ("human-physical adaptive systems"). This research will principally engage physical scientists, computer scientists, and engineers, consistent with the ACI, to conduct research collaboratively with biological, neural, and social scientists to bridge gaps in human-machine interfaces, and, in doing so, create new, natural interfaces. New methodologies will break the long-standing paradigm that requires the human to adapt to the requirements of the machine. The requested funding will enable selective small, high-risk, transformative research projects, consistent with the mandate of the America COMPETES Act, to explore promising research directions in this emerging field.

Potential for Impact: AST has high impact potential stemming from two paradigm-shifting concepts. First, it uses the "time-tested" analog of human and machine nervous systems to accelerate the design and development of innovative and adaptive technologies at the human-machine interface. Second, it employs a framework and research questions that naturally integrate the scientific disciplines with engineering in an area of technology that is primed for growth.

Integration of Research and Education: A full realization of AST requires truly interdisciplinary scientists and engineers. An investment in AST will create a dynamic environment to educate the next generation of scientists and engineers and train them to integrate knowledge from separate disciplines, as well as work together collaboratively. More generally, AST will be inspirational—drawing students into science and engineering because of the awe-inspiring increases in human productivity and accomplishment that can be imagined at the human-machine interface.

Leveraging Collaborations: NSF is taking full advantage of its greatest strength, a broad representation of science and engineering in one organization. BIO, CISE, ENG, MPS and SBE will support this activity.

Urgency and Readiness: Our knowledge of biological structures and processes in the nervous system is growing exponentially, largely because of non-invasive, multi-modal measurement tools that have time, position, and chemical resolution properties that were previously unobtainable. This greatly expanded understanding of the form and function of living neural systems can lead us to quantum leaps in the theory and technologies of adaptive control systems. An August 2006 workshop of leading scientists and engineers concluded that this field of human-physical adaptive systems stands at "a moment of revolutionary change in the kinds of questions that can be asked and the kinds of answers that can be achieved." Investments in Europe and Asia have increased substantially. The US community of scientists and engineers stands ready to hasten this avenue of discovery and urges haste to avoid lost opportunities.

Evaluation and Management: Success will be measured in discoveries that advance basic theory and in the application of that theory to answering questions of relevance to science and society. Novel collaborations will be expected among practitioners that promise to stimulate and sustain a "culture of innovation" in the United States. The development of innovative technologies and products will be measured by the number of new patents, the development of startup companies, expanded economic activity derived, and the hiring of new faculty in the area of Adaptive Systems Technologies. Assessment of the program will be conducted through community workshops, principal investigator meetings, and formal Committee of Visitor reviews. The program will be successful if external evaluators judge that it has effectively fostered discoveries in critical areas that lead to innovation, expanded economic activity, and service to society.

Funding: The Request is for $15.0 million in FY 2009.

NATIONAL SCIENCE FOUNDATION CENTERS

NSF supports a variety of centers programs that contribute to the Foundation's mission and vision. Centers exploit opportunities in science, engineering, and technology in which the complexity of the research problem or the resources needed to solve the problem require the advantages of scope, scale, duration, equipment, facilities, and students. Centers are the principal means by which NSF fosters interdisciplinary research.

NSF Centers Funding
(Dollars in Millions)

	Program initiation	Number of Centers in FY 2007	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Centers for Analysis & Synthesis	1995	2	$6.67	$13.41	$18.41	$5.00	37.3%
Centers for Chemical Innovation[1]	1998	8	3.00	7.50	20.00	12.50	166.7%
Engineering Research Centers	1985	15	47.05	52.86	53.55	0.69	1.3%
Materials Research Science & Engineering Ctrs	1994	26	55.97	54.73	62.73	8.00	14.6%
Nanoscale Science & Engineering Centers	2001	18	38.61	42.59	44.61	2.02	4.7%
Science and Technology Centers	1987	17	68.56	64.95	76.02	11.07	17.0%
Science of Learning Centers	2003	6	12.64	14.94	15.00	0.06	0.4%
Total, Centers			$232.50	$250.98	$290.32	$39.34	15.7%

Totals may not add due to rounding.
[1] Formerly titled Chemical Bonding Centers.

CENTERS DESCRIPTIONS

Centers for Analysis and Synthesis (BIO)

The Centers for Analysis and Synthesis are designed to continue development of new tools and standards for management of biological information and meta-information, support data analysis capabilities with broad utility across the biological sciences, host workshops that bring together scientists from a variety of disciplines, and begin to host and curate databases. The centers have a critical role in organizing and synthesizing biological knowledge that is useful to researchers, policy makers, government agencies, educators, and society.

The National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California at Santa Barbara promotes integrative studies of complex ecological questions and serves as a locus for the synthesis of large data sets. The National Evolutionary Synthesis Center (NESCent) is a collaborative effort by Duke University, North Carolina State University, and the University of North Carolina at Chapel Hill to foster a greater conceptual synthesis in biological evolution by bringing together researchers and educators, extant data, and information technology resources.

The Center for Research at the Interface of the Mathematical and Biological Sciences (CIMBS) will be established in FY 2009 to stimulate research and education at the interface of the mathematical and biological sciences. The Center will play a critical role in addressing national needs, particularly in the area of modeling infectious diseases of animals and plants, and will provide knowledge that will be useful to policy makers, government agencies, and society. Although predominantly supported by BIO, MPS will also contribute to CIMBS.

Lastly, a Plant Science Cyberinfrastructure Collaborative (PSCIC) will be established in FY 2008 to create intellectual synergy among biologists, computer and information scientists, mathematicians, engineers, and others to drive discovery and enable new conceptual advances through integrative, computational approaches. In FY 2009, PSCIC will receive increased funding to use advanced computational and cyberinfrastructure capabilities and expertise to craft solutions to an evolving array of grand challenges in biology.

Centers for Chemical Innovation (formerly Chemical Bonding Centers) (MPS)
The Centers for Chemical Innovation (CCI) are designed to support research on strategic, transformative "big questions" in basic chemical research. The program is stimulating the chemical sciences community to perform work that is high-risk and of potential high scientific and societal impact, particularly through innovation. CCIs promote the integration of research and education through the extensive involvement of students and postdoctoral fellows in all phases of the work. The Centers are expected to be agile, responding to scientific opportunities as they arise, and to creatively engage the public, Grand challenges include emulating and even surpassing the efficiency of the natural process of photosynthesis to capture the sun's energy; learning how molecules combine to become living things; activating strong bonds as a means to store and use chemical energy and to lower energy costs in chemical processing; and designing self-assembling, complex structures, such as molecular computers, with emergent and useful functions not even yet known or foreseen.

The first Center awarded in FY 2007 is developing chemistry needed to transform raw materials such as plants into high value organic compounds such as fuels and chemicals for industry. Developing centers are designing nanostructured catalysts to promote the solar-powered conversion of water into hydrogen and oxygen, using new laser methods to probe elementary chemical events on ultrasmall and ultrafast scales, and designing molecular machines powered by chemical bonds.

The program is designed as a staged competition, supporting several Phase I centers ($500,000 per year for three years), which then compete for Phase II awards ($4.0 to 5.0 million per year for five to ten years). In FY 2009, the requested $12.50 million increase will launch three new Phase II Centers (for a total of five) and three new Phase I Centers (for a total of six).

Engineering Research Centers (ENG)
NSF's Engineering Research Centers (ERCs) are proven cauldrons of innovation, bridging the energy and intellectual curiosity of universities with the real-world applications of industry-focused research. These centers also are uniquely successful in educating a technology-enabled workforce with hands-on, real-world experience. These characteristics create an environment that catalyzes the development of marketable technologies to generate wealth and address engineering grand challenges, many of which intersect with the Administration's American Competitiveness Initiative. This is particularly evident in ERCs that address hydrogen as an alternative fuel, biomedical healthcare innovations, and multimedia information systems.

ERCs succeed in these areas because they provide the intellectual foundation for industry collaboration with faculty and students to resolve long-range challenges, continue the steady advances in technology, speed their transition to the marketplace, and train graduates who are effective in applying them in industry. ERCs are also devoted to the integration of research and education by creating collaborative environments for learning and research, and producing curricula and course materials for bioengineering, manufacturing, electronic packaging, and particle science and technology, among others. Also, all ERCs have active programs to stimulate interest in engineering among pre-college students and their teachers; several have sites at local museums to educate the general public about engineering and technology.

During the last few years, the ERC program, established in 1985, has seen the total number of centers supported increase from the historical level of 15 to a peak of 19. Concurrently, the number of proposals received by the Directorate for Engineering research programs has increased dramatically causing a significant drop in funding rate across the Directorate. As the next generation of ERCs come online, the number of centers will fall back to the historical level of 15. In FY 2008, five new ERCs are planned to replace graduating centers in order to maintain the total at 15. Funding in FY 2009 will increase slightly as these five new ERCs ramp up their activities, but no new awards are planned.

Materials Research Science and Engineering Centers (MPS)
Materials Research Science and Engineering Centers (MRSECs) address fundamental materials research problems of intellectual and strategic importance that are critical for American competitiveness and the development of future technologies. MRSECs also support shared experimental facilities, place strong emphasis on the integration of research and education at all levels, and provide seed support to stimulate emerging areas of materials research. They support cutting-edge materials research in areas such as electronic and photonic materials, polymers, biomimetic and biomolecular materials, magnetic and ferroelectric materials, nanoscale materials, structural materials, and organic systems and colloids. MRSECs have strong links to industry and other sectors, enabling the development of marketable technologies that depend on new classes of materials and the discovery, control, and innovative exploitation of materials phenomena. Areas of potential technological impact include computers and communications, transportation, energy storage, structural engineering, health, and medicine. MRSECs also foster research and education partnerships among academic institutions in the U.S. as well as international partnerships. A significant component of new MRSEC awards are expected to tie to Foundation-wide activities, particularly Science and Engineering Beyond Moore's Law.

There are now 26 MRSECs. Open competitions for NSF support are held triennially. The 2005 competition yielded two new centers devoted to genetically engineered materials and to interfaces in electronic and magnetic materials, respectively. Three other centers are currently phasing out with final funding in FY 2007. A new competition is planned for FY 2008, from which three new centers are expected to be supported; funding for these new centers will be ramped up in FY 2009.

Nanoscale Science and Engineering Centers (multi-directorate)
Nanotechnology, which addresses technology on the smallest of scales, is projected to be one of the largest drivers of technological innovation for at least the next decade and beyond. This potential was recognized in the National Nanotechnology Initiative and more recently in the American Competitiveness Initiative, particularly in the burgeoning area of nanomanufacturing. Research at the nanoscale through NSF-funded Nanoscale Science and Engineering Centers aims to advance the development of the ultra-small technology that will transform electronics, materials, medicine, environmental science, and many other fields. Each center has a long-term vision for research. Together they provide coherence and a long-term outlook to U.S. nanotechnology research and education; they also address the social and ethical implications of such research. Support will be provided for education and outreach programs from K-12 to the graduate level, designed to develop a highly skilled workforce, advance pre-college training, and further public understanding of nanoscale science and engineering. The centers have strong partnerships with industry, national laboratories, and international centers of excellence, which puts in place the necessary elements to bring discoveries in the laboratory to real-world, marketable innovations and technologies.

There are 18 NSECs, including the National Nanotechnology Network and Nanotechnology in Society Network. Four NSECs on nanomanufacturing have established the core of the National Nanomanufacturing Network in FY 2007. The Center for Environmental Implications of Nanotechnology, with an annual budget of $4.0 million, will be competed in FY 2008.

Science and Technology Centers: Integrative Partnerships (multi-directorate)
The Science and Technology Centers: Integrative Partnerships (STC) program advances discovery and innovation in science and engineering through the integration of cutting-edge research, excellence in education, targeted knowledge transfer, and the development of a diverse workforce while broadly advancing the goals and objectives of the American Competitiveness Initiative. The STC research portfolio reflects the disciplines of science and engineering supported by the NSF. Examples of continuing investment include cyber-security, advanced sensors and embedded networked sensing, revolutionary materials for information technology, advanced nano/microfabrication capabilities, new materials and technologies for monitoring water resources and water quality, medical devices, modeling and simulation of complex earth environments for improving their sustainability, and weather/climate prediction. STCs engage the Nation's intellectual talent and robustly draw from its full human diversity through partnerships among academia, industry, national laboratories, and government. These partnerships result in synergistic effects that enhance and ensure the timely transfer of knowledge and technology from the laboratory to appropriate industries, the application of patents derived from the work of the STCs, the launching of spin-off companies, and creation of job opportunities. Furthermore, STCs have impressive records of publications and research training of undergraduate students, graduate students, postdoctoral fellows, established researchers, and educators as well as contributions to K-12 education, industry, and other sectors.

In FY 2008, support for five centers from the Class of 2000 program will begin to phase out with full program sunset in FY 2009. A new competition is planned for FY 2009 with five to seven new STCs expected to be named.

Science of Learning Centers (multi-directorate)
The Science of Learning Centers (SLC) goals are to advance fundamental knowledge about learning, transform the way people learn and teach, secure the U.S. leadership role in innovation and technology, and prepare the Nation's workforce for the 21st century.

The six existing SLCs will continue to harness and integrate knowledge across multiple disciplines to create a common groundwork of conceptualization, experimentation, and explanation that underlie new lines of thinking and inquiry leading to a deeper understanding of learning. The SLC portfolio represents synergistic, exciting research efforts that address different dimensions of learning, including:

- combined modeling and experimental studies to link brain function and behavior and permit innovations in technology;
- development of learning technologies to study robust learning in classrooms so that new principles can inform use and design of new technologies that enhance learning;
- the processes involved in learning visual languages and how this knowledge can improve language processing and reading in deaf, hearing-impaired, and hearing learners;
- the influence of time and timing on learning across multiple scales and multiple levels of analysis, to inform understanding of learning from the cellular level to social interactivity in classrooms;
- the interplay between learning in informal and formal environments; and

- spatial intelligence and learning, the malleability of the underlying processes and how they can be enhanced to improve learning in STEM domains.

In FY 2009, $15.0 million will provide continuing support for the second cohort of SLCs and for programmatic activities, including administration costs, workshops, Small Grants for Exploratory Research, and supplements for program infrastructure and development.

Estimates of Centers Participation in 2007
(Dollars in Millions)

	Number of Participating Institutions	Number of Partners	Total FY 2007 NSF Support	Total Leveraged Support	Number of Participants
Centers for Analysis & Synthesis	4	20	$7	$2	1,463
Centers for Chemical Innovation	60	23	$3	$5	445
Engineering Research Centers	494	455	$47	$181	4,647
Materials Research Science & Engineering Centers	200	219	$56	$45	5,190
Nanoscale Science & Engineering Centers	140	280	$39	$17	5,350
Science & Technology Centers	100	355	$69	$35	2,495
Science of Learning Centers	29	59	$13	$10	586

No. of Participating Institutions: all academic institutions participating in activities at the centers.
No. of Partners: the total number of non-academic participants, including industry, states, and other fed agencies at the centers.
Total Leveraged Support: funding for centers from sources other than NSF.
No. of Participants: the total number of people who use center facilities, not just persons directly support by NSF.

Centers Supported by NSF in FY 2007

Center	Institution	State
Centers for Analysis and Synthesis		
National Center for Ecological Analysis and Synthesis (NCEAS)	U of California-Santa Barbara	CA
National Evolutionary Synthesis Center (NESCent)	Duke, NC State U, U of N. Carolina	NC
Centers for Chemical Innovation (formerly Chemical Bonding Centers)		
Activation and Transformation of Strong Bonds (CATSB)	U of Washington	WA
Center for Molecular Cybernetics	Columbia	NY
Chemical Design of Materials	U of California-Santa Barbara	CA
Chemistry at the Space-Time Limit: Time Resolved Nonlinear Spectroscopy of Elementary Chemical Events	U of California-Irvine	CA
Darwinian Chemical Systems	Mass. General Hospital	MA
Orchestrating Proton Transport Through Supramolecular Alignment of Functionalities	U of Massachusetts-Amherst	MA
Powering the Planet: A Chemical Bonding Center for the Direct Conversion of Sunlight into Chemical Fuel	California Institute of Technology	CA
The Origins Chemical Inventory and Early Metabolism Project	Georgia Institute of Technology	GA
Engineering Research Centers		
Advanced Engineering Fibers and Films	Clemson	SC
Biomimetic Microelectronic Systems	U of Southern California	CA
Collaborative Adaptive Sensing of the Atmosphere	U of Mass-Amherst	MA
Compact and Efficient Fluid Power	U of Minnesota	MN
Computer-Integrated Surgical Systems and Technologies	Johns Hopkins	MD
Engineering of Living Tissue	Georgia Institute of Technology	GA
Environmentally Beneficial Catalysis	U of Kansas	KS
Extreme Ultraviolet Science and Technology	Colorado State	CO
Mid-IR Tech for Health and the Environment	Princeton	NJ
Power Electronic Systems	Virginia Tech	VA
Quality of Life Technology	Carnegie Mellon/U of Pittsburgh	PA
Structured Organic Composites	Rutgers	NJ
Subsurface Sensing and Imaging Systems	Northeastern	MA
Synthetic Biology	U of California-Berkeley	CA
Wireless Integrated MicroSystems	U of Michigan	MI
Materials Research Science and Engineering Centers		
Center for Complex Materials	Princeton	NJ
Center for Materials for Information Technology	U of Alabama	AL
Center for Materials Research	Cornell	NY
Center for Materials Science and Engineering	Mass Institute of Technology	MA
Center for Micro- and Nanomechanics of Materials	Brown	RI
Center for Multifunctional Nanoscale Materials Structures	Northwestern	IL
Center for Nanomagnetic Structures	U of Nebraska	NE
Center for Nanoscale Science	Pennsylvania State	PA
Center for Nanostructured Interfaces	U of Wisconsin	WI
Center for Nanostructured Materials	Columbia	NY
Center for Polymer Interfaces and Macromolecular Assemblies	Stanford, UC-Davis, IBM	CA
Center for Research on Interface Structures and Phenomena	Yale	CT
Center for Response-Driven Polymeric Films	U of Southern Mississippi	MS
Center for Science and Engineering of Materials	California Institute of Tech	CA
Center for Semiconductor Physics in Nanostructures	U of Oklahoma, U of Arkansas	OK, AR
Ferroelectric Liquid Crystals Materials Research Center	U of Colorado-Boulder	CO
Genetically Engineered Materials Science and Engineering Center	U of Washington	WA
Laboratory for Research on the Structure of Matter	U of Pennsylvania	PA

Materials Research Center	U of Chicago	IL
Materials Research Science and Engineering Center	Harvard	MA
Materials Research Science and Engineering Center	U of California-Santa Barbara	CA
Materials Research Science and Engineering Center	U of Maryland	MD
Materials Research Science and Engineering Center	U of Minnesota	MN
Materials Research Science and Engineering Center	Carnegie Mellon	PA
Materials Research Science and Engineering Center	Johns Hopkins	MD
Materials Research Science and Engineering Center on Polymers	U of Massachusetts	MA
Nanoscale Science and Engineering Centers		
Affordable Nanoengineering of Polymer Biomedical Devices	Ohio State	OH
Center for Environmental Implications of Nanotechnology	To be completed in FY 2008	tbd
Center for Integrated and Scalable Nanomanufacturing	U of California-Los Angeles	CA
Directed Assembly of Nanostructures	Rensselaer Polytechnic Institute	NY
Electronic Transport in Molecular Nanostructures	Columbia	NY
High Rate Nanomanufacturing	Northeastern, U of New Hampshire, U of Mass-Lowell	MA
Integrated Nanomechanical Systems	U of Calif-Berkeley, Cal Tech, Stanford, U of California-Merced	CA
Integrated Nanopatterning and Detection Technologies	Northwestern	IL
Molecular Function at the Nano/Bio Interface	U of Pennsylvania	PA
Nanotechnology in Society Network: Center at ASU	Arizona State U	AZ
Nanotechnology in Society Network: Center at UCSB	U of California-Berkeley	CA
Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems	U of Illinois-Champaign-Urbana	IL
Nanoscale Systems in Information Technologies	Cornell	NY
Nanoscience in Biological and Environmental Engineering	Rice	TX
National Nanomanufacturing Network: Center for Hierarchical Manufacturing	U of Massachusetts-Amherst	MA
Probing the Nanoscale	Stanford, IBM	CA
Science of Nanoscale Systems and their Device Applications	Harvard	MA
Templated Synthesis and Assembly at the Nanoscale	U of Wisconsin-Madison	WI
Science and Technology Centers		
Adaptive Optics	U of California-Santa Cruz	CA
Advanced Materials for Water Purification	U of Illinois	IL
Behavioral Neuroscience	Georgia State	GA
Biophotonics Science and Technology	U of California-Davis	CA
Center for Remote Sensing of Ice Sheets (CReSIS)	U of Kansas	KS
Coastal Margin Observation and Prediction	Oregon Health and Science U	OR
Earth Surface Dynamics	U of Minnesota	MN
Embedded Networked Sensing	U of California-Los Angeles	CA
Environmentally Responsible Solvents and Processes	U of North Carolina	NC
Integrated Space Weather Modeling	Boston U	MA
Layered Polymeric Systems	Case Western Reserve U	OH
Materials and Devices for Information Technology Research	U of Washington	WA
Microbial Oceanography: Research and Education	U of Hawaii	HI
Multi-Scale Modeling of Atmospheric Processes	Colorado State U	CO
Nanobiotechnology	Cornell	NY
Sustainability of Semi-Arid Hydrology and Riparian Areas	U of Arizona	AZ
Ubiquitous Secure Technology	U of California-Berkeley	CA
Science of Learning Centers		
A Center for Learning in Education, Science, & Technology (CELEST)	Boston U	MA
Pittsburgh Science of Learning Center - Studying Robust Learning with Learning Experiments in Real Classrooms	Carnegie Mellon	PA

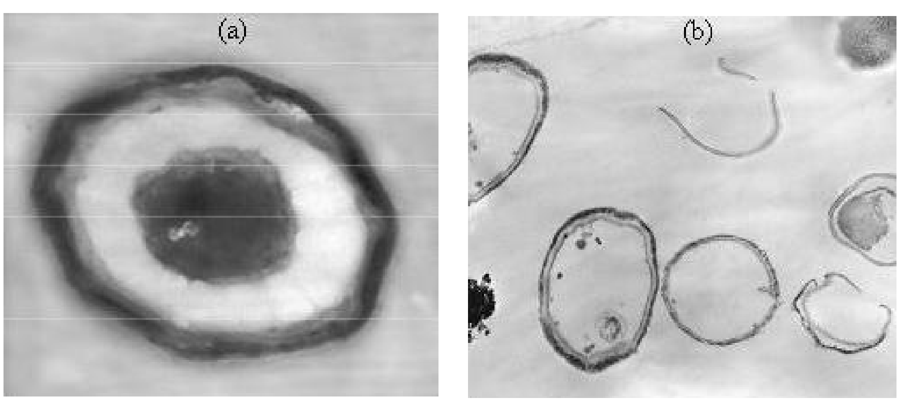
The LIFE Center - Learning in Formal and Informal Environments	U of Washington	WA
Spatial Intelligence and Learning Center (SILC)	Temple	PA
The Temporal Dynamics of Learning Center (TDL)	U of California-San Diego	CA
Visual Language and Visual Learning (VL2)	Gallaudet	DC

Recent Research Highlights

Experimental Model Systems. *Credit: Center for Behavioral Neuroscience, Atlanta, Georgia.*

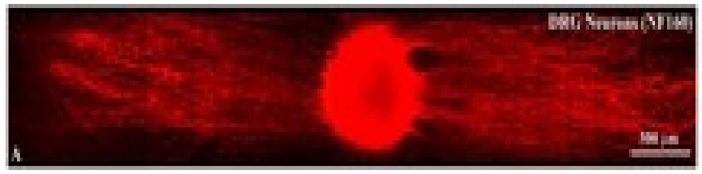
► **Where Biology Meets Business**: The NSF-funded Center for Behavioral Neuroscience in Atlanta, Georgia is making great strides at improving how undergraduates view science. It helps transfer relevant discoveries from the laboratory to the public, with programs such as its BioBusiness Seminar Series, which brings together undergraduate science and business students to learn how their two disciplines merge in companies that commercialize bioscience products. The program makes students aware of job opportunities and fosters development of applied technology and business-oriented culture in the universities while training potential management-level employees. It also educates new generations of research scientists and students in innovative, interdisciplinary ways of investigating the neural basis of social behavior. (BIO/STC).

► **Using Visible Light to Destroy Pathogens in Water**: Chemical byproducts from disinfecting water can be toxic or can cause cancer. A safer way to treat water uses light to destroy pathogens but problems with titanium dioxide catalysts have stymied this approach. Using nanomaterials, researchers at the Center of Advanced Materials for the Purification of Water with Systems, an NSF Science and Technology Center, developed effective titanium dioxide catalysts. This removes the primary obstacle to using light for water treatment and makes it possible to use visible light, rather than UV, to disinfect drinking water. (ENG/STC).

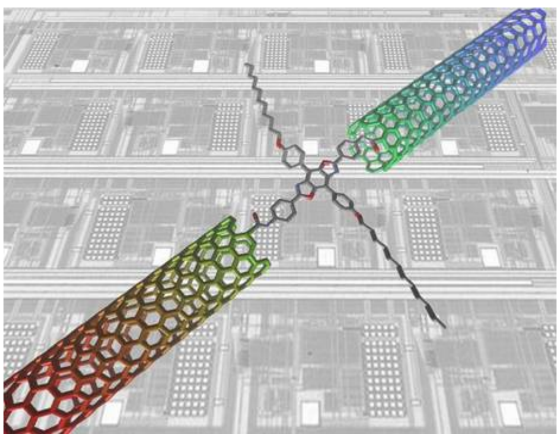


Transmission electron microscopy image of bacillus spores before (left) and after (right) photocatalytic treatment by visible light-illuminated metal doped TiON. *Credit: Mark Shannon, University of Illinois.*

► **Synthetic Scaffolds to Repair Nerves**: Today most damaged nerves are replaced with grafts from a patient's own nerves. However, appropriate grafts may not be available and infection is a risk when transplanting tissue and organs. Researchers from the Georgia Tech/Emory University Center for the Engineering of Living Tissues (an NSF-funded Engineering Research Center) have used polymeric nanofibers to develop a biocompatible material that functions as a scaffold on which new nerve tissues can grow. The method paves the way for safer, more cost effective nerve regeneration. By offering topographical cues to guide cell alignment, the polymer scaffolds matched the performance of an autograft across a long nerve gap in rodents. This research lays the foundation for off-the-shelf engineered polymeric grafts to repair damage to peripheral nerves. (ENG/ERC).



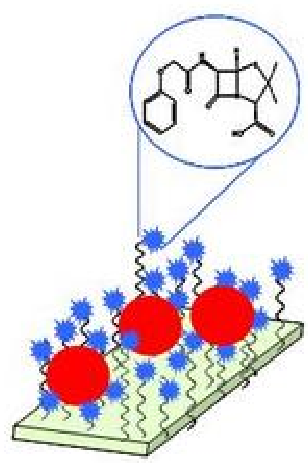
A fluorescent image of nerve cells in a chick. The red lines show regeneration along the nanoscaffolds. *Credit: GTEC.*



A nanotube electrode developed for directly measuring the conductance of single molecules. *Credit: Image created by Dr. Colin Nuckolls, graduate student Jinyao Tang, and Dr. Shalom Wind of the Columbia Nanocenter. Funding provided by NSF and the New York State Office of Science, Technology, and Academic Research.*

► **How to Solder an Individual Molecule to an Electrode**: How can we solder an individual molecule to an electrode structure? A multidisciplinary team from the Columbia University Nanocenter answered that question. They developed a new method to wire molecules directly into nanometer-scale gaps in conducting single-walled carbon nanotubes. They precisely cut a single-walled carbon nanotube using oxygen to make a carbon-oxygen-terminated electrode separated by a gap of d10 nanometers. The chemical species at the gap is a carboxylic acid. When the point contacts are exposed to another kind of molecule – one with a nitrogen – they react to form carbon-oxygen-nitrogen bridges between the molecule and the nanotube. These chemical contacts are robust and have allowed the team to test conductance in a wide-variety of molecules. This research will spur rapid progress in the drive towards molecular level electronics. (MPS/NSEC).

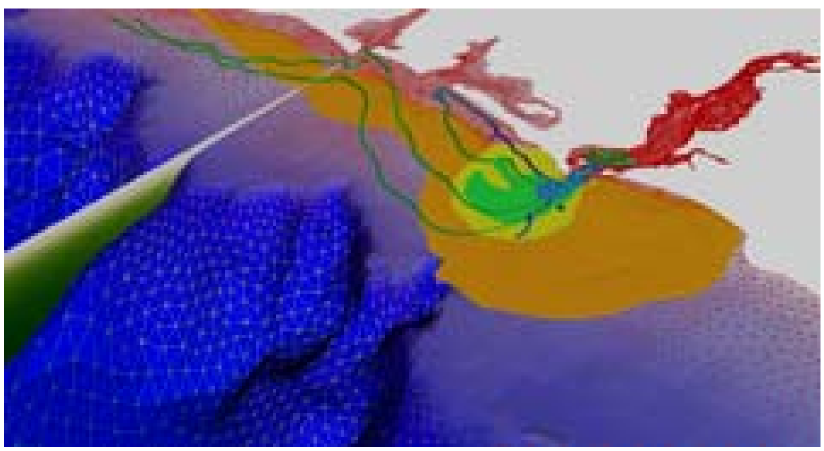
► **Penicillin-Coated Polymer for Medical Devices**: Researchers at the Materials Research Science and Engineering Center at the University of Southern Mississippi chemically attached penicillin to expanded polytetrafluoroethylene (PTFE) to produce an antibacterial surface that kills *Staphylococcus aureus,* the most common cause of staph infections. Expanded PTFE is a highly porous polymer commonly used in waterproof fabrics such as Gore-Tex. It is also extensively used in medical devices and implants. This means that antibiotics can be built into objects that are inserted into the body rather than giving patients antibiotics to ward off infections. The research team is now working on attaching an array of drugs to expanded PTFE. They are exploring blood clotting and applying other antibiotics to surfaces for control of an array of bacteria. (MPS/MRSEC)



This cartoon shows the penicillin molecule as a blue puffball attached to the surface of expanded PTFE by a spacer. Bacteria is shown as large red balls. The spacers allow the penicillin to surround the bacteria – killing it. The chemical structure of penicillin is shown in the bubble. *Credit: Marek Urban.*

► **Studying Coastal Margins Using Observation and Prediction Technologies**: Coastal margins are among the most densely populated and developed regions in the United States. At the same time they are highly complex ecosystems, sensitive to many scales of variability. Natural events and human activities place stresses upon coastal margins, rendering the development of sustainable coastal resources and ecosystems difficult and contentious, with policy decisions sometimes based on insufficient understanding of the consequences of natural and anthropogenic phenomena.

In 2006, NSF awarded a grant to support a new Science and Technology Center for Coastal Margin Observation and Prediction (CMOP). CMOP will enable researchers to focus on novel technological and scientific opportunities to solve major science questions on the impact of climate on coastal margins, the role of coastal margins on global elemental cycles, and the seaward extent of human impacts. Integral to CMOP is a river-to-ocean testbed observatory for the Pacific Northwest, consisting of modeling systems, observation networks, and information systems all aimed at fundamental advancements in science and the delivery of more reliable information to scientists, educators, resource managers, and interested citizens. This work will lead to transformative understanding of critical yet vulnerable coastal ecosystems. (GEO/STC).



The image depicts selected aspects of the dynamics of the Columbia River plume, in winter. Downwelling-favorable winds drive the plume to the North, forming a narrow coastal jet. Shown are constant salinity surfaces and pathways of three virtual drifters, all of which released from inside the estuary. Simulations were conducted with unstructured-grid 3D circulation models and are a part of the modeling system of a river-to-ocean coastal observatory for the Columbia River estuary and plume. *Credit: Paul J. Turner*.

CLIMATE CHANGE SCIENCE PROGRAM

Climate has a pervasive effect on the U.S. through its impact on the environment, natural resources, and the economy. To respond to the challenge of understanding climate and climate variability, the Climate Change Science Program (CCSP) was established in 2002 (www.climatescience.gov) as a follow-on to the US Global Change Research Program (USGCRP). It is providing the Nation and the world with the science-based knowledge to predict change, manage risk, and take advantage of opportunities resulting from climate change and climate variability. Research conducted through CCSP builds on the scientific advances of the last few decades and deepens our understanding of how the interplay between natural factors and human activities affect the climate system. The CCSP engages thirteen U.S. agencies in a concerted interagency program of basic research, comprehensive observations, integrative modeling, and development of products for decision-makers. Consistent with the FY 2009 Interagency Implementation Priorities memo, NSF provides support for the broad range of fundamental research activities that form a sound basis for other mission-oriented agencies in the CCSP and the Nation at large.

The Earth's climate is determined by highly complex interactions between and among the atmosphere, hydrosphere, cryosphere, geosphere, and biosphere. NSF programs address these components by investing in fundamental discovery, utilizing the full range of intellectual resources of the scientific community; research infrastructure, to provide advanced capabilities; and innovative educational activities. As a key participating agency in the CCSP, NSF encourages interdisciplinary activities and focuses particularly on Earth system processes and the consequences of change. High priorities for the agency include data acquisition and information management activities necessary for global change research, the enhancement of models designed to improve our understanding of Earth system processes, the development of new, innovative Earth observing instruments and platforms, and the development of advanced analytic research methods. NSF also supports fundamental research on the general processes used by organizations to identify and evaluate policies for mitigation, adaptation, and other responses to varying environmental conditions. Through its investment, NSF contributes to CCSP by providing a comprehensive scientific foundation for many of the synthesis and analysis products identified in the CCSP Strategic Plan.

Climate Change Science Program Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Biological Sciences	$15.10	$15.10	$15.10
Engineering	1.00	1.00	1.00
Geosciences	157.72	157.72	164.72
Mathematical and Physical Sciences	6.81	5.45	6.00
Social, Behavioral and Economic Sciences	15.50	15.48	15.48
Office of Polar Programs	10.50	10.50	18.30
Total, Climate Change Science Program	$206.63	$205.25	$220.60

Totals may not add due to rounding.

FY 2009 Areas of Emphasis:

Atmospheric Composition – NSF programs in tropospheric and stratospheric chemistry will continue in FY 2009 to address the composition of the atmosphere and its relation to climate variability and change, and linkages between the atmosphere and the biosphere, land surface, oceans, and cryosphere. Studies of the transport and transformation of gaseous constituents and aerosols provide insights into the radiative and cloud nucleating properties of the atmosphere. Greenhouse gases are particularly important since they are the principal absorbers and re-radiators of heat. Results of these studies serve as important inputs for the assessment reports of the Intergovernmental Panel on Climate Change (IPCC).

Climate Variability and Change – In FY 2009, NSF programs will continue to emphasize climate variability and change across temporal and spatial scales, supporting observational campaigns and numerous analytical and modeling activities. These activities will help to address biases in global climate models. Ocean science efforts will concentrate on changes in ocean structure, circulation, and interactions with the atmosphere to improve our current understanding of the processes and models that address future changes, particularly those that may happen abruptly. The Community Climate System Model will continue to improve by incorporating additional complexity so that the model will better incorporate aerosol radiative forcing, stratospheric dynamics, interactive chemistry and biogeochemical cycles. Analyses of model output will focus on extreme climate events, such as hurricanes, droughts, and major ecological disturbances, in order to determine the mechanisms responsible and to evaluate their representation in models. Studies of paleoclimatology will continue to be supported as a means to provide baseline data on natural climate variability from the past and from key climatic regions. These studies improve our understanding of the natural variability of the climate system and in particular will enable reconstructions and evaluations of past environmental change as inputs for model validations.

The Global Water Cycle – NSF supports research to understand all aspects of the global water cycle. Relevant programs will continue to explore ways to utilize more effectively the wide range of hydrologic data types – continuous and discrete information from a variety of platforms – for research purposes. Information from process studies will be used to refine models through parameterizations of sub-grid processes, particularly the fluxes of water through the Earth system. High resolution cloud system models are being refined to address the persistent problems of moist convection and cloud processes – two of the more challenging and uncertain components in climate change calculations. Fifteen prototype observatories are being established to explore critical scientific issues related to the design of hydrologic observatories. The first established observatory is part of the Sustainability of Semi-arid Hydrology and Riparian Areas (SAHRA) Science and Technology Center and works with stakeholders in translating research advances into useful products and addressing uncertainty.

Land-Use and Land-Cover Change – Several NSF programs continue to address key aspects of land-use and land-cover change through studies in ecological rates of change and related species diversity, Arctic systems, temporal variability, water and energy influences on vegetative systems, and diverse human influences on land use.

Global Carbon Cycle – NSF provides support for a wide variety of carbon cycle research activities, for critical long-running oceanic time series stations and the Keeling CO_2 record, as well as for planning and data management. FY 2009 investigations will continue to examine a range of topics in terrestrial and marine ecosystems and their relations to the carbon cycle. Research in terrestrial settings will explore, for example, carbon storage, delivery of carbon by rivers, carbon fluxes from high-latitude soils, carbon export from mountains, and submarine groundwater discharge in the oceans, ocean acidification and remineralization in mesopelagic zones. Carbon cycle studies will integrate observational data into models to provide insights for understanding key aspects of the global carbon cycle and feedbacks on the climate system and on strategies to investigate and adapt to climate change through CO_2 sequestration.

Ecosystems – Several NSF programs address terrestrial and marine ecosystems through observational, experimental, modeling, and laboratory studies. The Long Term Ecological Research (LTER) Program supports the collection of time-series data on key ecosystem processes and funds research on the drivers of ecosystem change in terrestrial and marine systems. The Global Ocean Ecosystem Dynamics program will continue to study the impact of global ocean changes on marine ecosystems through specific synthesis activities focused on the North Atlantic and the North Pacific. Research will continue to focus on understanding the impact of increasing carbon dioxide levels on the calcification rates, productivity and symbiotic relationships of hermatypic (reef-building) corals.

Human Contributions and Responses – NSF supports basic research on the processes through which people (individually, in groups, or through organizations) interact with natural environmental systems. FY 2009 funding supports projects that focus on decision-making under uncertainty associated with climate change. These projects are expected to produce new knowledge and tools that should facilitate improved decision-making by various stakeholder groups trying to deal with uncertainties associated with future climate variability and change.

Recent Research Highlights

► **Climate Change Impacts on Water Supply:** Climate scientists from the Scripps Institution of Oceanography and the Lawrence Livermore National Laboratory are collaborating with researchers from the NSF-funded San Diego Supercomputer Center to ascertain how global climate change is affecting water supply in the western U.S. The scientists first run a model of the global climate on supercomputers, "zoom in" to see the impact in the western U.S., and analyze the findings and verify the model accuracy by comparing results with real-world observations. Scientists are challenged with how to handle large amounts of generated data--many terabytes (a terabyte is one thousand gigabytes). To manage the data, move it between institutions, and share it, researchers are using a special tool, called the "Storage Resource Broker," developed by the San Diego Supercomputer Center.

Supercomputer predictions of climate change impact on water flow in the Columbia River. *Credit: Amit Chourasia, SDSC/UCSD.*

► **Advancing U.S. Leadership in Climate Research and Education**: Project Atmospheric brown clouds (ABC) is a concerted effort among an international group of distinguished atmospheric scientists and researchers, governments in Asia, and research institutions in Asia, Europe, and the United States to address the causes and impacts of atmospheric brown clouds, which are a major environmental challenge facing the Asia-Pacific region. Unlike issues such as greenhouse gases and global warming, the effects on climate from pollution aerosols and other impacts are universally accepted throughout Asia. Project ABC provides high visibility for the United States in its leadership role on climate research and education in the South and Asia-Pacific region, which is home to more than half of the world's population.

ABC Training School at Hanimaadhoo, Maldives. *Credit: V. Ramanathan.*

► **Long-Term Study Leads to Elegant Understanding: Nitrogen Cycling:** The release of nitrogen from decaying roots and leaves into the soil provides plants with this essential nutrient. Analyses of data from a ten-year study in 21 diverse ecosystems indicate that the amount of nitrogen released into the soil is almost universally controlled by the same two factors: the initial concentrations of nitrogen and the mass of remaining organic matter in the decaying roots and leaves. This finding led to the formulation of simple equations for modeling nitrogen release that are applicable to almost every type of ecosystem. By simplifying the calculation of nitrogen release, these equations will improve our understanding of plant growth and therefore improve the accuracy of carbon uptake calculations in global climate models.

Three types of bags were used in the Long-Term Intersite Decomposition Experiment. The mesh size on each bag varied to exclude different organisms from decomposing the leaves or roots in the bag. *Credit: Mark Harmon*

CYBER-ENABLED DISCOVERY AND INNOVATION

In the last 50 years, investments in fundamental research led to science and engineering innovations and the suite of computational algorithms, concepts, methods, models, and tools that drive today's economy. The Nation's preeminence in science and engineering is unquestionably recognized as an essential element of competitiveness in the economic, social, and technology sectors. As indicated in NSF's "*Cyberinfrastructure Vision for the 21st Centur*y," the infusion of advanced computational capabilities into the traditional experimentation-observation-analysis-theory research paradigm is now revolutionizing how we conduct STEM research and education.

The Cyber-enabled Discovery and Innovation (CDI) investment promotes the advancement of science and engineering along fundamentally new pathways opened by computational thinking. Investments in FY 2009 will contribute to the agency's strategic goal of advancing the frontier of science and engineering knowledge by creating new computational concepts, methods, models, algorithms, and tools that promise a wave of innovations in the public and private sectors for years to come. These investments will also contribute the preparation of a workforce with the computational competencies critical to continued U.S. competitiveness. In addition, they will lead to the development and innovative use of cyberinfrastructure that will accelerate the process of converting discovery into useful constructs.

FY 2008 will be the inaugural year for the agency's CDI investment. In FY 2009, the agency will build upon the core themes developed for FY 2008, highlighting new activities that hold significant promise for economic competitiveness and societal impact. These themes fall into two major dimensions of technical focus: From Data to Knowledge and Understanding System Complexity. A cross-cutting third dimension, Virtual Organizations, focuses on how science and innovation across geographic, disciplinary, and cultural boundaries will be increasingly practiced in the future. All of NSF's investments in CDI also support the interagency NITRD program.

From Data to Knowledge: Analyzing animal and plant genomes for markers of disease risk or resistance, discovering new fundamental particles, and observing new planets and proto-stars—all are like "finding a needle in a haystack." Research advances in From Data to Knowledge include but are not limited to new fundamental mathematical and computational abstractions to represent and manage data, multidisciplinary and international efforts on knowledge extraction, including data mining, data federation, and extraction strategies in demanding scientific applications, and the development of sophisticated data manipulation, visualization and delivery tools. These advances will help individuals, organizations, and society at large derive new knowledge from an abundance of digital data. As one example, in FY 2009 researchers will undertake an Earth-system science approach to Arctic and Antarctic studies, addressing the synthesis of multidisciplinary data relating to system-scale environmental change observed in both regions.

In FY 2009, researchers will explore a new computing paradigm called Data-Intensive Super Computing (DISC). In DISC systems, storage and computation are co-located, providing fast interactive response time to the end user. To realize the full potential of DISC, we need innovative basic research in algorithms, programming languages, programming models, resource management, and system design. With the massive amounts of data collected and generated in science and in everyday life, DISC systems can transform application areas from science and engineering, to healthcare, finance, and the humanities.

Understanding Complexity in Natural, Built, and Social Systems: Future generations of computational algorithms, concepts, methods, models, and tools will enable scientists to better understand complexity in systems found in nature, built by humans, and manifest in society. Researchers will shed new light on protein folding, the flow of electricity across networks, and "tipping points" when new species evolve or languages undergo major structural shifts. They will develop principles for scaling from the quantum- to the nano- to the macro-scales in complex systems, and design and synthesize new resilient complex engineering systems, such as materials, sustainable resilient civil infrastructure, etc. Characteristics common to complex systems are the large number of interacting elements, the non-linearity of these interactions, and/or aggregate or emergent phenomena observed within and across multiple scales. For FY 2009, we highlight two themes, to recognize the need for predictive models and simulation for harnessing complexity and the critical reliance on software in the operation of complex systems:

- **Computational Simulation and Prediction.** Predicting turbulence in airflow over aircraft wings, the collapse of financial markets, or the occurrence of natural disasters such as earthquakes and tornadoes are examples of where improving our capability to predict could have direct impact on the frontiers of science and engineering, and national competitiveness. The development and use of computational methods for predicting the behavior of highly dynamic features in the environment will change the way we study and understand challenging problems, including weather forecasting, interactions between climate variability, biogeochemical cycles and ecosystems, coastal zone management, and natural disaster recovery. Simulation and computational models have emerged as important investigative tools for understanding complex physical, social, engineering, and life science phenomena, and will significantly impact the health and safety of all citizens and the stability of the national economy. The next generation of predictive models must offer the ability to rapidly synthesize design alternatives for systems and processes of unprecedented scales; they must capture temporal dynamics and spatial variations in a unified fashion, across large-scale heterogeneous media, systems and processes.

- **Software for Complex Systems.** Society is witnessing a growth in and reliance on cyber-physical systems, such as smart automobiles, sensor nets for environmental monitoring, and embedded medical devices; and similarly, in mobile, portable, and pervasive computing devices, such as cell phones, digital cameras, flexible displays, multi-media multi-modal handhelds, and household robots. It is the software that integrates these and other complex systems into a seamless, globally networked, 24/7 world. Teams of multidisciplinary researchers will work together to explore the engineering of software for complex systems with complementary themes: (1) exploring scientific and engineering principles, e.g., inspired by complexity sciences, for developing software for tomorrow's complex cyber-based systems, and (2) exploiting computational models underlying software systems to understand natural and physical systems. Research outcomes in this area are potentially enormous. Innovations in software and software services contribute more than $1.7 trillion to the global economy, making U.S. competitiveness in this area essential to our continued economic prosperity.

Virtual Organizations: Virtual organizations built upon cyberinfrastructure to link teams of people and resources distributed across institutional and geographic boundaries are increasingly essential for science and engineering, enabling global collaborations. We are just beginning to explore their potential to enhance discovery, learning, and innovation. CDI investments support interdisciplinary research to create more systematic knowledge about the intertwined social and technical issues of effective virtual organizations, changing both how we practice research and what we produce from it. FY 2009 activities focus on building and applying more principled understanding of the design of effective virtual organizations needed to achieve the flexibility and agility to respond to new and emerging challenges in an increasingly competitive knowledge-based economy. This focus includes exploration of virtual organizations as a primary vehicle for broadening participation in not just research but also exciting inquiry-based STEM education, with the potential to reach students at all levels and the public at large.

Cyber-enabled Discovery and Innovation

(Dollars in Millions)

FY 2008 Estimate	FY 2009 Request
$47.90	$100.00

CYBERINFRASTRUCTURE

Science and engineering have undergone a revolution in which the traditional approach of observation, experimentation, theory, and analysis has been dramatically enhanced by use of advanced computing and communication technology with information in digital form. Digital interfaces found in modern laboratory equipment can be networked to make it possible for scientists to directly participate in experiments from across the country or around the globe. Wired, wireless, and optical networking and the growth of autonomous systems enable researchers to deploy elaborate webs of sensors in domains as diverse as environmental science and astronomy. Advances in the analysis and visualization of digital data permit researchers to analyze large, complex collections of data. Information technology has made it possible for groups of collaborating researchers to overcome distance and work together more effectively as they tackle the hard problems of modern science and engineering.

In parallel with the emergence of digital technologies that increase the capabilities of researchers, the questions at the forefront of scientific and engineering research have become increasingly complex. Researchers wish to unravel the way multiple processes, interacting over multiple space and time scales, produce the rich variety of phenomena seen in complex systems. Such complex systems permeate the natural and engineered world, from the intricate workings of a cell to the emergence of structure in the early universe and the workings of the internet. Advances in understanding in the digital realm are providing the tools that help researchers tackle the new research challenges in the physical, biological, and social sciences.

Cyberinfrastructure Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Biological Sciences	$90.50	$97.13	$99.78
Computer and Information Science and Engineering	71.00	87.00	87.00
Engineering	54.00	56.00	60.00
Geosciences	75.00	75.00	80.00
Mathematical and Physical Sciences	61.21	64.56	71.06
Social, Behavioral and Economic Sciences	20.60	20.54	20.54
Office of Cyberinfrastructure	182.39	185.33	220.08
Office of International Science and Engineering	1.30	0.75	0.75
Office of Polar Programs	43.70	26.24	26.24
Subtotal, Research and Related Activities	$599.70	$612.55	$665.45
Education and Human Resources	17.74	16.25	16.50
Total, Cyberinfrastructure Funding	$617.44	$628.80	$681.95

Totals may not add due to rounding.

The term ***cyberinfrastructure*** was coined to encompass many of the systems used for working with digital information that have the potential to fuel advances in research, education, industry, and society. NSF has supported pioneering efforts by researchers:

- to understand the scientific foundations and develop components of cyberinfrastructure, mainly through investments made by the Directorates for Computer and Information Sciences, Mathematical and Physical Sciences, and Engineering;

- to use these components to break new ground in science and engineering research through investments made by all NSF directorates and the Office of Cyberinfrastructure, and
- to investigate how cyberinfrastructure should be integrated into the research and education enterprise, mainly through investments made by the Office of Cyberinfrastructure and the Direcorate for Computer and Information Science and Engineering.

The success of these and related programs has demonstrated the power of cyberinfrastructure and caused many research communities to express an urgent need both for greater access to and for new types of cyberinfrastructure.

Extensive input from the research and education communities led NSF to develop the document, *A Cyberinfrastructure Vision for the 21st Century,* which defines NSF's leadership roles in an integrated system of high performance computation services, services for managing massive and heterogeneous data/information, sensing and observation across multiple scales of time and space, multimode visualization and interaction, and distributed team collaboration. It also describes learning and workforce issues associated with applying cyberinfrastructure to learning as well as the learning required to use cyberinfrastructure. Achieving the vision requires linking three complementary activities: 1) research and development of tools, concepts, and technologies; 2) provisioning of leading-edge cyberinfrastructure systems; and 3) the application of cyberinfrastructure to advance our understanding of the world around us, respond to emergencies, and provide more authentic and motivational STEM learning opportunities for students, teachers, professionals, and the general public. Investments in FY 2009 are designed to capitalize on the results of the pioneering early forays into cyberinfrastructure and to advance research and education through the implementation of the strategies laid out in this vision.

Grand challenges in many fundamental research areas will benefit from investments in cyberinfrastructure. For example, analyses of DNA sequence data are providing remarkable insights into the origin of life, revolutionizing our understanding of the major kingdoms of life, and revealing stunning and previously unknown complexity in microbial communities. Sky surveys are changing our understanding of the earliest conditions of the universe and providing comprehensive views of phenomena ranging from black holes to supernovae. Researchers are monitoring socio-economic dynamics over space and time to advance our understanding of individual and group behavior and their relationship to social, economic, and political structures. Using combinatorial methods, scientists and engineers are generating libraries of new materials and compounds for health and engineering, and environmental scientists and engineers are acquiring and analyzing streaming data from massive sensor networks to understand the dynamics of complex ecosystems.

The American Competitiveness Initiative (ACI) describes the goal of providing world-leading high-end computing capability, coupled with advanced networking, to enable scientific advancement through modeling and simulation at unprecedented scale and complexity across a broad range of scientific disciplines. NSF investments in high-performance computing for research and education, the TeraGrid infrastructure, middleware investments, and international network connections directly contribute to the goals of the ACI. The enormous growth in the availability and utility of cyberinfrastructure capabilities, both technology- and human-based, is increasing the productivity of scholarly research, accelerating the transformation of research outcomes into products and services that drive economic growth, and enhancing the effectiveness of learning across the spectrum of human endeavor.

All NSF activities participate in support for cyberinfrastructure. The Office of Cyberinfrastructure (OCI) makes investments common to a broad range of science and engineering fields, promoting economies of scale and scope, and facilitating interoperability. Other directorates and offices make complementary cyberinfrastructure investments necessary to meet their disciplinary missions. Some highlights of NSF's FY 2009 investments, led by the designated activity, follow:

- Continued investments in the Plant Science Cyberinfrastructure Collaborative (PSCIC), a new type of organization – a cyberinfrastructure collaborative for plant science – will enable new conceptual advances through integrative, computational thinking. The collaborative will utilize new computer, computational science, and cyberinfrastructure solutions to address questions in plant science. The collaborative will be community-driven, involving plant biologists, computer and information scientists, and experts from other disciplines working in integrated teams. (BIO)

- SBE's Science of Science and Innovation Policy (SciSIP) activities are developing an evidence-based platform from which policymakers and researchers may assess the impacts of the Nation's science and engineering (S&E) enterprise, improve their understanding of its dynamics, and predict outcomes. Specifically, data collection, research, and community development components of SciSIP's activities will: (a) improve and expand science metrics, datasets, and analytical tools, yielding changes in the bi-annual S&E indicators and other data collections; (b) develop usable knowledge and theories of creative processes and their transformation into social and economic outcomes; and (c) build a community of experts in this area across the federal government, industry, and universities. SciSIP supports the development of new data, models, and tools, and also facilitates transformative research on an immensely policy-relevant topic — the ecology of innovation. SBE is at the forefront internationally of the collection of data on the S&E workforce and research and development statistics. These data, in conjunction with the new theoretical models and analytical tools being developed with support from SciSIP, will inform and enhance the success of the ACI. In addition, the Innovation and Organizational Change program focuses attention on the effects of innovative cyberinfrastructure on companies and scientific laboratories. (SBE)

- Continued support will be provided for the development of a versatile, open-source, community Ocean Modeling Environment and to identify and refine best practices and describe trade-offs between alternatives for simulating a range of important ocean processes. A second thrust is to develop and assess the capability to dynamically configure the grid resolution of future ocean models. The Budget Request also supports work of the Community Surface Dynamics Modeling System (CSDMS), a national effort to develop, support, and disseminate to the geoscience research and teaching community, integrated software aimed a predicting the erosion, transport, and deposition of sediment and solutes in landscapes and their repository sedimentary basins. A key science issue to be explored by this initiative includes understanding the fluxes, reservoirs, and flow paths associated with the physical, biological, and chemical transport processes in the Critical Zone -- the skin of the earth. Both projects will have considerable societal impacts. Finally, the Request supports a variety of projects that will develop or maintain community databases. (GEO)

- The Computational Infrastructure for Geodynamics (CIG) will develop, support, and disseminate software for the geoscience community, from model developers to end-users. The software is designed to investigate problems ranging widely from mantle and core dynamics, crustal and earthquake dynamics, magma migration, and seismology. The long-term goal of CIG is to create a set of computational tools and data structures that can be commonly applied within the geodynamics community. A common set of computational tools will enable the development of models of Earth evolution that intimately couple lithosphere, convecting mantle and core, with the capability to eventually simulate the planet as a whole. (GEO)

- Continued support will be provided for software and services that facilitate complex science and engineering research and that advance ACI goals in data-intensive applications. These include innovative approaches to data management and stewardship, and middleware for distributed applications, distributed collaboration, interactive remote observation and the tele-operation of experimental facilities. Continued investment in leading-edge computational infrastructure and international network connections will support the research of U.S. investigators and their ability to collaborate internationally in projects such as the Large Hadron Collider (LHC). Investments will be made in numerical models, data analysis tools and new algorithms in strategic science and engineering research areas in order to take advantage of forthcoming petascale computing systems. (OCI)

- Our society now faces the mammoth challenge of synthesizing information and deriving knowledge from massive, dynamic, ambiguous and possibly conflicting digital data. In FY 2009, CISE researchers will create the foundational computational concepts, models, tools, and algorithms that will allow human-centered visualization systems of the future to more effectively create new knowledge from data. (CISE)

- Continuing investments will be made in the Directorate for Education and Human Resources to support a national resource of high-quality internet-based STEM educational content. (EHR)

- Improved understanding and design approaches will be pursued for auto-reconfigurable engineered systems enabled by cyberinfrastructure. Autonomous reconfigurability is a promising concept for ensuring appropriate operational levels during and after unexpected natural or man-made events (e.g. hurricanes, pandemics, or terrorist attacks) that could impact critical engineered systems in unforeseen ways. (ENG)

- The International Geophysical Year (IGY: 1957-1958) or International Polar Year (IPY-3) ushered in the modern era of polar research and provided the first detailed measurements of the polar ocean, atmosphere, land, and space. Emerging advances in cyberinfrastructure that occur during the IPY (2007-2009) will for the first time link remote instruments with scientists in the field and institutions around the world, allowing scientists to observe and record the pulse of our planet in real-time. (OPP)

- Continued cyberinfrastructure support will be provided for the Arctic Systems Sciences (ARCSS) Data Coordination Center that serves as a central point for deposition of data deriving from ARCSS-funded research. Continued support is also provided for Arctic modeling, distributed field sites, and autonomous flux towers. In the Antarctic, funds support data center/data repositories, 3-D bathymetric data fusion, and environmental monitoring, both marine and terrestrial. In addition, support is provided for the engineering, operations and maintenance, and security of cyberinfrastructure systems. (OPP)

- Research at the frontiers of mathematical and physical sciences spans multiple length and time scales, ranging from studies of elementary particles to studies of nuclear, atomic, and molecular properties, dynamics, and reactions to the discovery of new materials and states of matter. At the other end of the length scale are studies of supernovae, structures in the universe, and space-time. Achieving a fundamental understanding of these diverse phenomena involves the use of cyberinfrastructure. In addition, cyberinfrastructure enables the prediction and discovery of new materials and of new states of matter. (MPS)

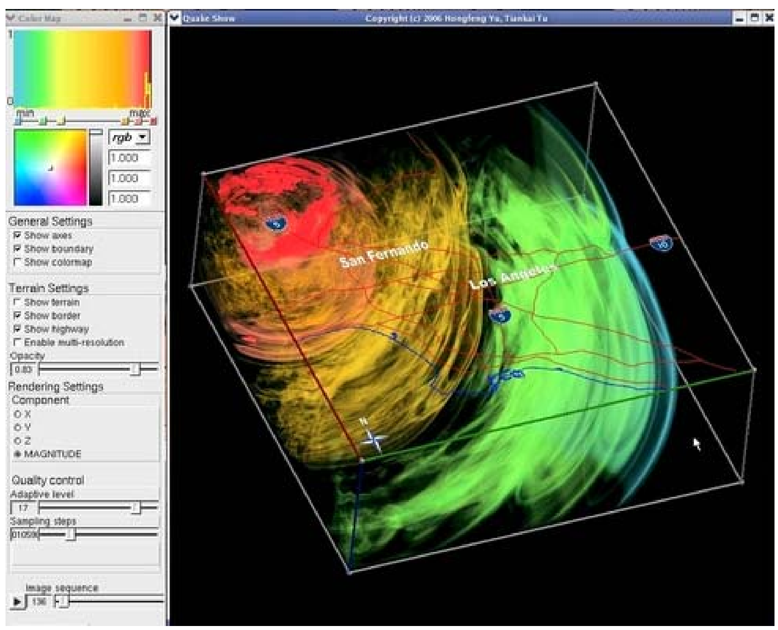
- Advances in the performance of information technology hardware bring previously computationally intractable problems within reach. Physical scientists and mathematicians contribute to the development of high-performance computing, high-speed networks, data mining, software, and algorithms. Cyberinfrastructure ensures community access to the best software for a wide range of research activities ranging from the interpretation of experimental data to the visualization of simulation results. It enables scientists and students to easily tap into the hundreds of terabytes of archived data available around the world. Such databases are fast becoming an essential component of the physical sciences research environment. Emphasis will continue on the development of global GRID network technology to enable discoveries to be made in petabyte data sets generated at unique facilities and involving international collaborations, *e.g.*, LIGO and LHC. (MPS)

- Distributed computing, where the public is able to download software that enables them to add their personal computers to the computations associated with a particular problem allows for a novel "collaboration" with the general public. Distributed computing directly connects with the NSF goal of enhancing discovery and understanding while promoting teaching, enhancing infrastructure for research and education, and broad dissemination to enhance scientific understanding. (MPS)

Over time, NSF investments will contribute to the development of a powerful, stable, persistent, and widely accessible cyberinfrastructure to enable the work of science and engineering researchers and educators across the Nation and around the world.

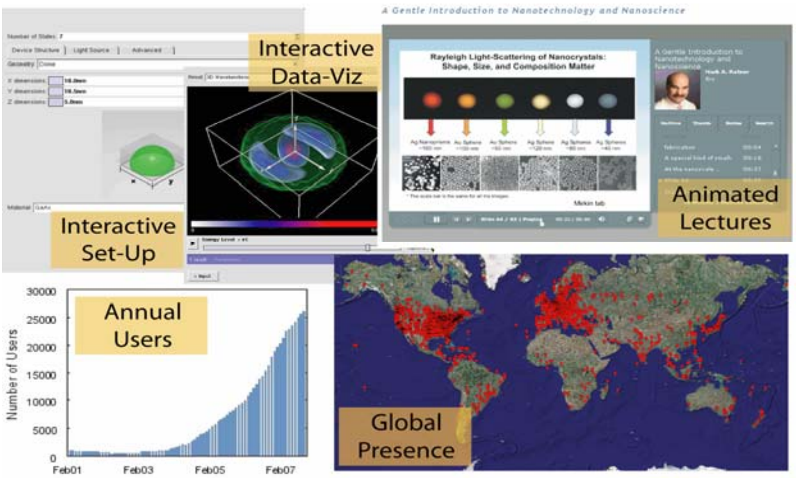
Recent Research Highlights

► **Earthquakes on Demand:** Researchers created a ground-breaking capability to use thousands of computer processors to simulate in fine detail earthquakes and other events. The process brings together diverse aspects of the computer science field to work on real scientific problems provided by earthquake scientists. The system enhances the ability of large supercomputer centers and networks to provide powerful tools that support scientists and engineers. These tools improve the ability to predict strong ground-motion during earthquakes and will eventually help zoning code developers produce more accurate building requirements. They will also make critical infrastructure, such as power-plants and waste facilities, safer. This work has wide-ranging effects in computer science, earth science, civil engineering, and computational modeling. (CISE)



The laptop screen during a real-time animation of a simulation of the 1994 Northridge earthquake, while the simulation is running on 2050 processors of the Cray XT3 at PSC. The animation shows the displacements of the ground over time. Onscreen controls allow the user to interactively change the parameters of the volume rendering algorithm while the simulation and rendering algorithms are running on the processors of a remote supercomputer. *Credit: Hongfeng Yu, Tiankai Tu, CMU.*

► **Economic Impact of Globus:** Globus was started in 1996 as a research project to identify enabling mechanisms for resource federation across enterprises. That work led to the creation of the widely used open source Globus Toolkit and to the large and aggressive "grid" community in eScience and industry. Intel, Raytheon, and Cisco have publicly described their Globus work, job ads abound for Globus experts, and IBM promotes Globus as its standard open source grid platform. The indirect impact of Globus is also significant. Virtually every major computer vendor has a "grid product," and most of the Fortune 500 companies have a "grid strategy." While some of the activity might be characterized as "just" clustering solutions, others are more ambitious resulting in significant benefits. (OCI)



nanoHUB user community. *Credit: Gerhard Klimeck, Purdue University*

► **Simulating Nanotechnology:** The NSF Network for Computational Nanotechnology (NCN), a network of six universities headquartered at Purdue, has a mission to accelerate the advancement of nanotechnology. The NCN also created a unique cyberinfrastructure, a nanoHUB, which offers online simulation on-demand, through an ordinary Web browser. Its third-generation middleware supports integrated data analysis and visualization capabilities without having to download, compile, or install software. Simulations run on powerful computers in the nation's grid infrastructure for unprecedented reach into laboratories, classrooms, and other areas for greater utilization. The user community has doubled every year, and the number of simulation users has quadrupled. It executed over 230,000 simulation jobs for more than 5,900 registered users nationwide. (OCI)

DYNAMICS OF WATER PROCESSES IN THE ENVIRONMENT

Goal: Increase our fundamental understanding of the Earth's freshwater systems and provide the scientific basis for decision-making about water resources.

Description and Scientific Rationale: One of our greatest environmental challenges is to ensure an adequate supply and quality of water for human use while maintaining the integrity of natural ecosystems. The economic vitality of the Nation relies on fresh water for agriculture, energy, manufacturing, and other industries. Understanding water dynamics is essential to understanding climate and environmental change. At multiple scales of time and space, water connects physical, geochemical, biological, and ecological processes. Water also links and integrates natural systems with human social systems. Nonetheless, there are many gaps in our basic scientific understanding of water dynamics and the impacts of human interventions and changing environmental conditions on them. Addressing this challenge will require integrated, multi-disciplinary, multi-scale research on the *Dynamics of Water Processes in the Environment*.

The NSF investment will:

- Promote fundamental research on the complex processes and feedbacks that affect the vulnerability and resilience of freshwater systems to climate and environmental change.
- Develop innovative, transferable concepts and models that can contribute to improved risk assessment, and mitigation and adaptation strategies; and to enhance decision-making in uncertain conditions.
- Enhance our ability to model complex freshwater systems from local to regional scales taking advantage of advanced observation networks, cyberinfrastructure, and integrated large databases.
- Develop a new generation of science and engineering investigators who are prepared to solve interdisciplinary problems in this field of research.
- Pursue new approaches to water re-use, conservation, and sustainability.
- Provide educational opportunities for students and the public.

The National Science Foundation draws scientists, engineers, and educators from across traditional boundaries to enable breakthrough research needed for better understanding of complex water systems and processes. Activities such as the Long Term Ecological Research program, the Critical Zone Observatories, the Coupled Natural and Human Systems program, and certain centers and collaboratories supported by the Biological Sciences, the Geosciences, Engineering, and the Social and Behavioral Sciences are well positioned to contribute to interdisciplinary research focused on these goals. Through NSF's excellent relationships with mission agencies that have responsibilities for water monitoring and management, the impact of NSF research is broadened for maximum outreach to stakeholders.

Potential for Impact: Improved knowledge of the Earth's water system is necessary for a robust economy and for our very survival. It is central to questions of the environment and climate change. It is essential for reliable forecasting related to agriculture, fisheries, energy production, human health, transportation, manufacturing, and waste management. NSF investment in this area responds to these national needs and transforms our understanding of freshwater systems.

Integration of Research and Education: Research on the Earth's water systems has appeal for students and the public, and this research will provide tremendous opportunities for collaboration, integrative training, and public outreach at the intersection of science and policy. This activity will promote institutional and educational curricular change that reflects the integrated aspects of environmental science and engineering.

Leveraging Collaborations: There are abundant opportunities for partnerships between NSF and other agencies, including the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the U.S. Department of Agriculture (USDA), the U.S. Environmental Protection Agency, and especially with the United States Geological Survey (USGS). USGS is a mission agency focused on providing reliable scientific information to better manage the Nation's natural resources, including water, and to minimize loss from natural disasters. Both NSF and USGS support tools and infrastructure in the form of observatories, networks, databases, and cyberinfrastructure. An example of a current collaboration is the Hydrologic Information System (HIS) developed at the University of Texas. This web-based system draws data from a myriad of digital hydrologic databases into a common format, enabling researchers to have easy access to data collected and stored by the USGS and other agencies. A new effort at this time will leverage the interest of the USGS to partner with NSF in this area. Working with them, other agencies, and the scientific community will clarify gaps in current understanding that are ready for exploration, consolidate partnership opportunities, and inform NSF's focus on fundamental research on water processes.

Urgency and Readiness: Drought and flooding were major news items in the past year, as were forest fires and landslides. These events focused public attention on their overwhelming economic impacts and highlighted the need to better understand how water systems determine the severity of these phenomena. Federal agencies must act quickly and in a focused effort to improve our understanding of the Nation's freshwater (e.g., reports of Science and Technology to Support Fresh Water Availability in the United States, OSTP-OMB Memorandum of 23 June 2006, OSTP-OMB Memorandum of 14 August 2007). In addition, water will be a key factor limiting the development of biofuels as energy alternatives.

Evaluation and Management: Assessment of the outcomes of this activity will be conducted through community workshops, principal investigator (PI) meetings, and Committee of Visitors reviews. In addition, Advisory Committees for the Geosciences, Biological Sciences, and Environmental Research and Education will help ensure that this activity meets its goals. The program will be successful if external evaluators judge that it has identified critical areas for future fundamental research and education, supported activities in those areas, built partnerships with other agencies that leveraged resources, was effectively and efficiently managed, defined a program with the potential to transform our understanding of the Earth's freshwater systems, and lead to innovations in water management and policy.

Funding: The Request is for $10.0 million in FY 2009.

NATIONAL NANOTECHNOLOGY INITIATIVE

NSF's contribution to the multiagency National Nanotechnology Initiative (NNI) encompasses the systematic understanding, organization, manipulation, and control of matter at the atomic, molecular, and supramolecular levels in the size range of 1 to 100 nanometers. Novel materials, devices, and systems – with their building blocks designed on the scale of nanometers – open up new directions in science, engineering, and technology with potentially profound implications for society. With the capacity to control and manipulate matter at this scale, science, engineering, and technology are realizing revolutionary advances in areas such as individualized pharmaceuticals, new drug delivery systems, more resilient materials and fabrics, catalysts for industry, and order-of-magnitude faster computer chips.

National Nanotechnology Initiative Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Biological Sciences	$54.71	$55.55	$56.60
Computer and Information Science and Engineering	12.89	12.22	11.00
Engineering	137.02	137.02	140.02
Geosciences	9.65	9.65	6.33
Mathematical and Physical Sciences	169.48	169.48	178.07
Social, Behavioral and Economic Sciences	1.67	1.67	1.67
Subtotal, Research and Related Activities	$385.42	$385.59	$393.69
Education and Human Resources	3.27	3.10	3.10
Total, National Nanotechnology Initiative	$388.69	$388.69	$396.79

Totals may not add due to rounding.

FY 2009 NNI Funding. NSF contributes to the goals and eight program component areas (PCAs) outlined in the NNI Strategic Plan (www.nano.gov). The modes of support include single investigator, multidisciplinary team, center, and network awards.

Fundamental Nanoscale Phenomena and Processes. The FY 2009 Request includes $141.66 million for fundamental research and education, with special emphasis on:

- *Novel phenomena, quantum control, and basic engineering processes* – to discover and understand phenomena and design processes specific at the nanoscale, including new phenomena in materials, mechanics, chemistry, biology, electronics, and optics. A focus will be on the understanding and use of self assembly from basic principles and on multiple scales. Potential applications include use of quantum phenomena in systems and quantum computing, and new devices and processes for advanced communications and information technologies.
- *Biosystems at the nanoscale* – to support study of biologically based or inspired systems that exhibit novel properties and potential applications. Potential applications include improved drug delivery, biocompatible nanostructured materials for implantation, exploiting of functions of cellular organelles, devices for research in genomics, proteomics and cell biology, food and plant systems, and nanoscale sensory systems, such as miniature sensors for early detection of cancer. A focus will be on understanding and simulation of cells, tissues, and nervous systems, with application to biomedicine and neuromorphic engineering.
- *Converging science and engineering at the nanoscale* – The convergence of nanotechnology with information technology, modern biology, and social sciences will reinvigorate discoveries and innovation in almost all areas of the economy. This theme includes investments in (a) nano-biology

interface and improving human performance, (b) nano-information interface research, and (c) nano-neurosciences.

- *Multi-scale, multi-phenomena theory, modeling, and simulation at the nanoscale* – to support theory, modeling, large-scale computer simulation and new design tools, and infrastructure in order to understand, control, and accelerate development in new nanoscale regimes and systems. A special focus will be on simulations with atomic precision, time resolution of chemical reactions, and for domains of engineering and biological relevance. Another focus will be on predictive methods of nanomaterials' macroscopic properties from their nanostructure.

Nanomaterials. The FY 2009 Request includes $62.45 million for discovery of novel nanoscale and nanostructured materials, and improving the comprehensive understanding of the properties of nanomaterials (ranging across length scales and including interface interactions). A special focus will be gaining control of nanoscale features and devices with the atomic level of precision. Another focus will be design and synthesis, in a controlled manner, of nanostructured materials with targeted properties. Research on the discovery, understanding, and control of materials at the nanoscale will be critical to the development and success of innovative technologies, including communications, catalysts, energy, healthcare, and manufacturing.

Nanoscale Devices and Systems. The FY 2009 Request includes $51.60 million for R&D that applies the principles of nanoscale science and engineering to create novel, or to improve existing, devices and systems. This includes the incorporation of nanoscale or nanostructured materials to achieve improved performance or new functionality, and developing new concepts to understand interactions among nanoscale devices in complex systems, including the physical, chemical, and biological interactions between nanostructures and device components. A special focus will be on the architecture and emerging behavior of nanosystems, and on nanomanufacturing of active nanostructures and nanosystems.

Nanoelectronics beyond silicon nanotechnology and complementary metal-oxide superconductors (CMOS) research will explore ultimate limits to scaling of features and alternative physical principles for devices employed in sensing, storage, communication, and computation. The research activity in this area will help develop innovative technologies, including replacing electron charge as information carrier, bottom-up device assembly technologies at the atomic and molecular levels, and new system architectures using nanoscale components.

A special focus will be on nano-informatics for better communication and nanosystem design. It includes defining the ontology of terms, interconnecting databases, using specific informatics tools, and connecting to bioinformatics.

Instrumentation Research, Metrology, and Standards for Nanotechnology. The FY 2009 Request includes $16.0 million for R&D to create new tools needed to advance nanotechnology research and commercialization, including next-generation instrumentation for characterization, measurement, synthesis, and design of materials, structures, devices, and systems. A special challenge is developing tools for measuring and restructuring matter with atomic precision, for time resolution of chemical reactions, and for domains of biological and engineering relevance.

Nanomanufacturing. The FY 2009 Request includes $26.90 million to support new concepts for high rate synthesis and processing of nanostructures, nanostructured catalysts, nanobiotechnology methods, fabrication methods for devices, and assembling them into nanosystems and then into larger scale structures of relevance in industry and in the medical field. R&D is aimed at enabling scaled-up, reliable, cost effective manufacturing of nanoscale materials, structures, devices, and systems. A special focus will be creating active nanostructures and complex nanosystems. This will include R&D and integration of ultra-miniaturized top-down processes, increasingly complex bottom-up or self-assembly processes, and developing novel concepts for high-rate synthesis and processing of nanostructures and nanosystems.

Major Research Facilities and Instrumentation Acquisition. The FY 2009 Request includes $32.09 million for user facilities, acquisition of major instrumentation, and other activities that develop, support, or enhance the scientific infrastructure for the conduct of nanoscale science, engineering, and technology research and development. It also supports ongoing operations of the National Nanotechnology Infrastructure Network (NNIN), Network for Computational Nanotechnology (NCN), National Network for Nanomanufacturing (NNN), and National High Magnetic Field Laboratory (NHMFL). The investment will support facilities for 17 ongoing Nanoscale Science and Engineering Centers (NSEC).

Environmental, Health and Safety. The FY 2009 Request includes $30.64 million, an increase of $1.45 million over the FY 2008 Estimate for research primarily directed at environmental, health, and safety (EHS) implications and methods for reducing the respective risks of nanotechnology development. Basic research will support understanding of underlying phenomena and processes. Research on both implications and applications of nanotechnology will address the sources of nanoparticles and nanostructured materials in the environment (in air, water, soil, biosystems, and working environment), as well as the non-clinical biological implications. The safety of manufacturing nanoparticles is investigated in eight center/networks: NSEC at Rice University (evolution of manufacturing nanoparticles in the wet environment), NSEC at Northeastern University (occupational safety during nanomanufacturing), NSEC at University of Pennsylvania (interaction between nanomaterials and cells), NSEC at University of Wisconsin, Madison (effect of nanostructured polymers on EHS), NSEC at University of California, Berkeley (building a system for detecting exposure to individual and portable nanomaterials), NSEC at the University of Ohio (nanoscale devices for monitoring and healing), NSEC at University of Massachusetts, Amherst, (clearinghouse on occupational safety), and National Nanotechnology Infrastructure Network (with two nanoparticle characterization centers at the University of Minnesota and Arizona State University). Environmental implications of nanotechnology, including development of new measurement methods for nanoparticle characterization and toxicity of nanomaterials will be investigated in a dedicated multidisciplinary center. It aims to conduct fundamental research on the interactions between nano-particles and materials and the living world at all scales. An essential element of this will be research on methods and instrumentation for nano-particle detection, characterization, and monitoring, including interactions of nano-materials with cellular constituents, metabolic networks and living tissues, bioaccumulation and its effects on living systems, and the impacts of nanostructures dispersed in the environment. This work will support regulatory and mission agencies in developing science-based standards for risk assessments, such as those needed by NIST, EPA, FDA and other agencies to develop standards for and to regulate nano-materials.

Education and Societal Dimensions. The FY 2009 Request includes $35.45 million, an increase of $1.68 million over the FY 2008 Estimate, for various research and other activities that address the broad implications of nanotechnology for society, including education and social aspects, such as:

- Education-related activities, such as development of materials for schools, curriculum development for nanoscience and engineering, development of new teaching tools, undergraduate programs, technical training, and public outreach ($29.96 million). Two networks for nanotechnology education with national outreach will be supported: The Nanotechnology Center for Learning and Teaching (NCLT) and the Network for Nanoscale Informal Science Education (NISE).
- Research directed at identifying and quantifying the broad implications of nanotechnology for society, including social, economic, workforce, educational, ethical, and legal implications ($5.49

million). The application of nanoscale technologies will stimulate far-reaching changes in the design, production, and use of many goods and services. Factors that stimulate scientific discovery at the nanoscale will be investigated, effective approaches to ensure the safe and responsible development of nanotechnology will be explored and developed, and the potential for converging technologies to improve human performance will be addressed. The Nanotechnology in Society Network will be fully operational in FY 2008.

Coordination with Other Agencies. The NSF program is coordinated with 25 departments and agencies through the National Science and Technology Council's subcommittee on Nanoscale Science, Engineering and Technology (NSET). Examples of specific coordination efforts are: Nanomanufacturing (DOD/NIST); Environmental issues (EPA/NIOSH/NIEHS/ USDA); NSECs, NNIN and NCN centers and networks (DOD/NASA/DOE/NIH); simulations in nanoelectronics (DOD/NASA); and research and training activities (DOD/NIH).

NNI by Program Component Area

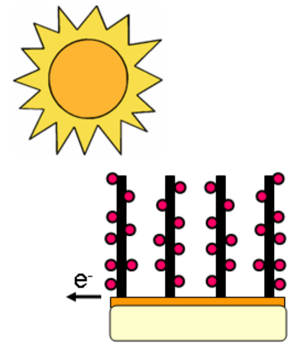
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Fundamental Nanoscale Phenomena & Processes	$145.17	$138.75	$141.22
Nanomaterials	58.37	62.14	63.05
Nanoscale Devices & Systems	52.36	50.32	51.60
Instr. Research, Metrology, & Standards for Nanotech	14.88	16.00	16.00
Nanomanufacturing	26.58	26.90	26.90
Major Research Facilities & Instrumentation Acquisition	30.03	31.62	32.09
Environmental Health & Safety	26.91	29.19	30.64
Education	28.97	28.28	29.80
Societal Dimensions: Ethical, Legal, Social Issues	5.42	5.49	5.49
Total, National Nanotechnology Initiative	$388.69	$388.69	$396.79

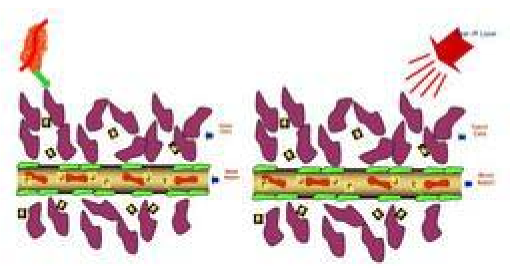
Totals may not add due to rounding.

Recent Research Highlights

► **Carbon Nanofiber Forests for Energy Conversion and Storage:** Materials with a very high surface area will be key to the success of emerging solar energy conversion technologies -- it is through the surface that a material interacts with the sunlight. Carbon nanofiber materials offer extremely high surface areas and individual fibers nanometers across that can conduct electricity. A research group at the University of Wisconsin-Madison is developing new energy-related chemistry technologies based on vertically aligned carbon nanofibers. They have discovered ways to grow nanometer scale catalysts such as platinum onto the carbon nanofibers in unprecedented high densities. Catalysts can accelerate chemical reactions, including those important in converting sunlight into electrical energy. This research explores the chemical synthesis of new nanomaterials and their potential application in energy conversion and storage and chemical sensing technologies. (MPS)



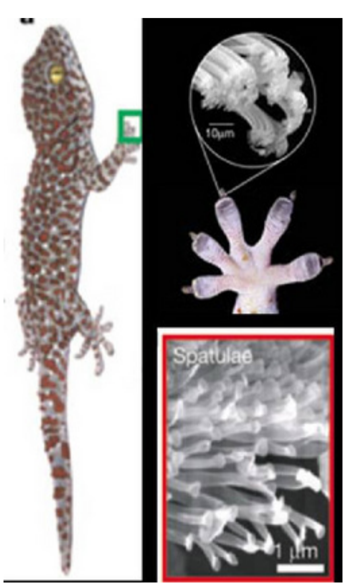
Schematic of vertically aligned carbon nanofiber (VACNF)-based solar energy conversion system. The VACNF forest collects sunlight and generates electricity (sunlight => electricity). Alternatively, the forest can generate hydrogen fuel (sunlight + water => hydrogen gas + oxygen gas).



Minimally-invasive nanotechnology-based cancer therapy. *Credit: Jon Schwartz, Nanospectra Biosciences Inc.*

► **Minimally-invasive Nanotechnology-based Cancer Therapy:** Researchers at Nanospectra Biosciences have developed AuroLase™ Therapy, a way to attack cancer by attaching nanoscale gold-silica markers to tumor cells and using lasers to destroy the tagged cells. The markers, which convert infrared light to heat, lodge within tumors by binding to specific receptors within the cell. When hit by light from the laser (which has no impact on normal cells), the particles heat up, killing the tumor cells. The treatment does not appear to have toxic side effects, is compatible with current cancer treatments, and has had promising results in early trials. (ENG)

► **Sticks Like a Gecko, But is 200 Times Stronger:** A few years ago, scientists discovered that geckoes don't have any special adhesive or suction cups on their feet but achieve their acrobatics from an ultradense carpet of hundreds of thousands of minuscule hairs that cover each foot. NSF-funded researchers at the University of Akron were able to create artificial materials--a dense brush of highly flexible and elastic carbon nanotubes held together by polymeric (plastic) material that emulate geckoes' sticking ability. These bio-inspired materials can adhere to any surface without any glues or suction cups and can even function under vacuum. In fact, this artificial "nano-brush" adheres to surfaces up to 200 times stronger than a gecko's foot. (MPS)



Ultra-dense carpet of fibers at the surface of gecko toes.
Credit: Professor A. Dhinojwala.

NETWORKING AND INFORMATION TECHNOLOGY R&D

The National Science Foundation is a primary federal agency supporting the Networking and Information Technology Research and Development (NITRD) program. All of the awards made by both the Directorate for Computer and Information Science and Engineering and the Office of Cyberinfrastructure enrich NSF's NITRD portfolio, with all of the agency's directorates making contributions in some way. Additionally, NSF makes research, education or research infrastructure investments in every NITRD Program Component Area (PCA). As in society at large, computing and information technology plays an increasingly important and expansive role in the agency's science and engineering award portfolio; in FY 2009, NITRD represents approximately 16% of the agency's budget.

Networking and Information Technology Research and Development Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Biological Sciences	$83.50	$83.50	$86.15
Computer and Information Science and Engineering	526.69	534.53	638.76
Engineering	11.20	19.20	28.01
Geosciences	14.56	15.56	18.98
Mathematical and Physical Sciences	73.70	70.89	73.72
Social, Behavioral and Economic Sciences	12.47	13.47	15.05
Office of Cyberinfrastructure	182.42	185.33	220.08
Subtotal, Research and Related Activities	$904.54	$922.48	$1,080.75
Education and Human Resources	3.91	9.00	9.50
Total, NITRD Request	$908.45	$931.48	$1,090.25

Totals may not add due to rounding.

NSF's FY 2009 Request continues strong support for the NITRD program. A number of promising new activities will help ensure that the agency's NITRD portfolio remains vibrant and focused on the scientific frontier, most notably the agency's enhanced investment of $100.0 million in Cyber-enabled Discovery and Innovation (CDI) and $20.0 million in Science and Engineering Beyond Moore's Law (SEBML).

CDI investments will create new computational concepts, methods, models, algorithms, and tools that promise a wave of innovations in science and engineering and in the public and private sectors for years to come. SEBML investments will lead to the new hardware, architectures, algorithms, and software needed to address challenges in computing systems, such as efficient input and output, data storage and internal communications, and reduction of energy dissipation, as well as optimizing computing power.

The NITRD Request of $1,090.25 million supports fundamental research and education and cyberinfrastructure deployment in:

- High-end computing infrastructure and applications (HEC I&A) involving advanced computer systems, applications software, and related infrastructure, critical to cutting-edge discovery across all scientific and engineering fields;
- High-end computing research and development (HEC R&D) activities to optimize the performance of today's high-end computing systems and to develop future generations of systems to meet critical needs;
- Cyber security and information assurance (CSIA) focusing on improving the ability of computing and information systems to prevent, resist, respond to, or recover from actions or events that compromise

or threaten the availability, integrity, or confidentiality of data, of the systems themselves, or of related services;

- Human-computer interaction and information management (HCI&IM) to increase the benefit of computer technologies to humans, particularly the science and engineering R&D community;
- Large-scale networking (LSN) for high-performance networking R&D in leading-edge networking technologies, services, and enhanced performance;
- High-confidence software and systems (HCSS) for systems and verification technologies to assure computer-based system safety, dependability, and correctness;
- Software design and productivity (SDP) leading to fundamental advances in concepts, methods, techniques, and tools for software design; and
- Social, economic, and workforce aspects of IT and IT workforce development (SEW) focusing on the nature and dynamics of IT impacts on technical and social systems, interactions between people and IT devices and capabilities, and workforce development needs.

NSF's Assistant Director for CISE is co-chair of the NITRD Subcommittee of the National Science and Technology Council's Committee on Technology. In addition, NSF works in close collaboration with other NITRD agencies and participates at the co-chair level in seven of the eight PCA Coordinating Groups.

NITRD Priorities in FY 2009

NSF is emphasizing investments in the following areas of NITRD in FY 2009:

Large Scale Networking ($95.79 million): CISE will continue support for activities for the Networking Technology and Systems (NeTS) program, including the Future Internet Design (FIND) program which focuses on revolutionary network architectures for the future.

Cybersecurity and Information Assurance ($87.55 million): NSF will continue to fund research on cybersecurity foundations, network security, and systems software that supports the objectives of the *Federal Plan for Cyber Security and Information Assurance Research and Development*. Emphasis will be placed on usability, privacy, and theoretical foundations. Support will continue for several centers, including one devoted to the scientific exploration of new technology that will radically transform the ability of organizations to design, build, and operate trustworthy information systems for critical infrastructure, and one investigating software architectures, tamper-resistant hardware, cryptographic protocols and verification systems as applied to electronic voting systems.

High-End Computing R&D ($91.49 million): NSF's new investment, Science and Engineering beyond Moore's Law, will focus on revolutionary new computing hardware technologies, as well as related programming models, languages and tools, all of which promise to inform the computing systems of the future. OCI and CISE will support the development of simulation, optimization and analysis tools that exploit the potential of petascale computing to advance the frontiers of scientific and engineering research.

High-End Computing Infrastructure and Applications ($298.43 million): Continuation of the acquisition of a high performance computing system in OCI is included at an annual level of $50.0 million. Several NSF directorates will increase their investments in this PCA to capitalize on the growing importance of cyberinfrastructure in furthering their research and education goals. For example, MPS and ENG will increase activity in modeling and simulation of complex systems; development of numerical algorithms and software implementations that push the boundaries of computing infrastructure; and use of the grid computing infrastructure.

MPS will strengthen support of research and education activities that contribute to and utilize the Virtual Astronomical Observatory, a federation of astronomical data bases. Support of other databases and digital libraries also will increase. MPS will support enhanced participation of remote access to instrumentation and increased connection of institutions that are distant from each other, such as a minority institution and its partner.

ENG will increase support of virtual organizations to leverage distributed physical experimentation, data collection, modeling and analysis capabilities using high-end computing and large scale networking infrastructures. ENG will also increase activity in modeling and simulation of complex systems; development of numerical algorithms and software implementations that push the boundaries of computing infrastructure; and use of the grid computing infrastructure.

BIO will invest in activities to broaden access to and usability of high performance computing resources in the biological sciences. Current biology applications claim substantial HPC computing resources that are narrowly focused in specific areas of biology. With increasing availability of large amounts of diverse data from plant, animal and microbial genomics to ecosystems modeling, additional areas of biology will likely require expanded access to and development of HPC resources.

GEO will continue to support state-of-the-art computing systems and data management services at the National Center for Atmospheric Research (NCAR). Part of this high performance computing environment, the Climate Simulation Laboratory (CSL), helps keep the U.S. at the forefront of 21st century climate science.

High Confidence Software and Systems ($67.62 million): As part of the CDI investment, CISE will support research on software for tomorrow's complex cyber-physical systems, such as smart automobiles, sensor nets for environmental monitoring, and embedded medical devices, and similarly in mobile, portable, and pervasive computing devices, such as cell phones, digital cameras, flexible displays, RFIDs, multi-media multi-modal handhelds, and household robots.

ENG will increase support of novel cyber-physical systems that combine the physical sensing and actuation functions with the computing and control functions into tightly-coupled high confidence systems.

Human Computer Interaction and Information Management ($266.52 million): The multidisciplinary CDI emphasis will focus on creation of new knowledge from digital data, including novel algorithms, data mining, and dimension reduction methodologies, new visualization methods to enhance human cognition, and innovative technologies to address data confidentiality, privacy, security, provenance, and regulatory issues.

NSF's new investment, Adaptive Systems Technology (AST), will support multidisciplinary research to generate creative pathways and natural interfaces between human and physical systems that will revolutionize the development of novel adaptive systems.

NSF will focus increased attention on the issues of federation, preservation, curation, and access to large, heterogeneous collections of scientific data and information. High capacity data management and high capacity computing are increasing challenges for a growing number of research communities. OCI will develop activities for a robust and resilient national and global digital data framework for preservation and access to the resources and products of the digital age. OCI will invest in data, modeling paradigm and software interoperability in the area of virtual organizations.

ENG's investment in this area will focus on creating new pathways to connect researchers with each other and with state-of-the-art experimental facilities. ENG will also invest in curation of data generated by the large number of geographically dispersed sensors that will be used for real-time control of complex systems.

BIO's investments in this area will facilitate discovery through tools that integrate the published literature with the expanding universe of digital data collections, expand capacity for understanding through virtual environments that provide an intuitive display of the complex networks of interactions among organisms and their environments, and make it practical for scientists to search vast collections of biological images simply and quickly.

Software Design and Productivity ($70.81 million): CISE will support research on the scientific and engineering principles for developing software for tomorrow's complex cyber-based systems. Advances in software foundations, including new computational models, techniques, languages, tools, metrics, and processes for developing and analyzing software for these complex systems, will be pursued.

ENG will invest in developing new algorithms and software that can efficiently scale to the petascale levels. ENG will also invest in virtual organizations to enhance the productivity of researchers by providing them access to computational tools, specialized facilities and observational data from anywhere in the world.

BIO, through its Biological Databases and Informatics program, will promote new ways of enabling science through the use of cyberinfrastructure, including new visual programming environments and integrated information systems that allow an entire community of experts to contribute simultaneously to understanding genome dynamics.

Social, Economic and Workforce ($112.04 million): Through CDI, NSF will support investments that infuse computational thinking into computing education at all levels and in all fields of science and engineering.

CISE will continue support to revitalize undergraduate education in computing through the CPATH program, begun in FY 2006. The CPATH vision is of a U.S. workforce with the computing competencies and computational thinking skills imperative to the Nation's health, security and prosperity in the 21st century. CISE also continues to support the Broadening Participation in Computing program, aimed at significantly increasing the number of students who are U.S. citizens and permanent residents receiving post secondary degrees in the computing disciplines.

OCI will support activities in cyberlearning that will pursue new opportunities for using cyberinfrastructure as a platform for providing effective online laboratory experiences to students and teachers. In collaboration with partners across NSF, OCI will support creative explorations and demonstrations of the use of cyberinfrastructure to integrate research with education, the development of innovative technologies that will facilitate the integration of research and education, and research on how educators and students interact with cyberinfrastructure along with exploring novel uses of cyberinfrastructure.

BIO will strengthen IT capabilities in all biological sub-disciplines through support for postdoctoral fellowships in bioinformatics; integrative graduate programs that combine training in biology and computer sciences (via the NSF-wide IGERT program); undergraduate summer institutes in bioinformatics through the interagency Bioengineering and Bioinformatics Summer Institutes program; and other mechanisms.

EHR will continue to study the impact of IT on educational practice, new approaches to using technology in education, application and adaptation of technologies to promote learning in a variety of fields and settings, and the effects of technology on learning, and efforts that advance teaching and learning opportunities in nanotechnology and/or cyberinfrastructure.

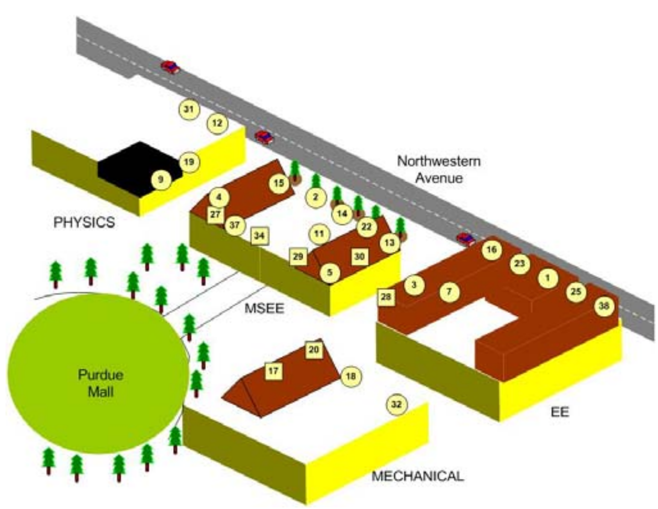
NITRD by Program Component Area
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Large Scale Networking	$83.50	$82.55	$95.79
Cybersecurity and Information Assurance	68.25	68.08	87.55
High End Computing R&D	64.68	78.57	91.49
High End Computing Infrastructure and Applications	275.43	257.42	298.43
High Confidence Software and Systems	52.40	56.63	67.62
Human-Computer Interaction and Info Management	219.34	234.82	266.52
Software Design and Productivity	51.00	54.81	70.81
Social/Economic/Workforce	93.85	98.60	112.04
Total, NITRD Request	$908.45	$931.48	$1,090.25

Totals may not add due to rounding.

Recent Research Highlights

► **Solving the "Last Mile Problem":** Small businesses and homes, representing the "last-mile problem" in telecommunications, stand to benefit from research being conducted at Purdue University on wireless mesh networks. Researchers are developing a high-performance mesh-network control plane designed to provide very-high data rates and low delays to end-users in a cost-effective manner. The large-scale development of such networks could pave the way for new broadband services such as high-definition video-conferencing, high-speed rural Internet access, distance education to the home, easy remote assistance for the disabled and sick, etc. This is a unique opportunity for the clean slate design of mesh networks, since these networks are not currently constrained by the shackles of legacy systems. An understanding



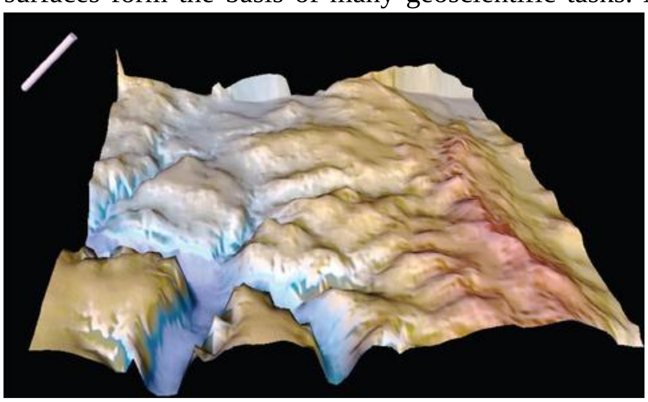
The Mesh@Purdue mesh network testbed has been extended to consist of 32 nodes, each with dual 802.11a/b radios. *Credit: Saumitra Das, Purdue University.*

of performance limits may finally provide answers to the "last mile" problem, resulting in a quantum advance in the ability to provide critical broadband services and applications to millions of end-users. Thus, the research has the potential to further increase the competitive edge that the U.S. holds in telecommunications. (CISE)

► **Development of a New Generation of Miniature Search and Rescue Robots:** Researchers have developed a miniature robot "scout" that can obtain reconnaissance and surveillance data in areas that pose significant risk to human beings or are unreachable in any other way. The robots have been designed to withstand repeated impact, which means that they can be thrown into position as well as be deployed from remote-controlled unmanned aerial vehicles. A number of these robots were delivered to the U.S. military for operation in Iraq and Afghanistan, where they are deployed in advance of ground forces, giving soldiers more time to think and react. A less expensive version of the robot, eROSI, has been used in a variety of educational, research, and outreach programs, including a robotics camp for middle school students from underrepresented groups. (CISE)

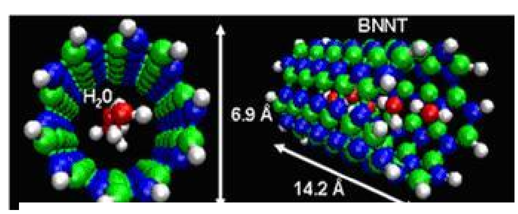
Top Right: A highly resilient robot "Scout" is displayed. Below Right: Students working with two eROSIs, the educational version of the "Scout." *Credit: Center for Distributed Robotics, University of Minnesota.*

► **Modeling 3-D Geologic Structures in a Multisensory Virtual Environment:** Three-dimensional surfaces form the basis of many geoscientific tasks. An NSF-funded project aims to create natural and intuitive ways for scientists to interact with these surfaces, while simultaneously presenting additional data to them. The first prototype uses a force-feedback device to feel the surface with a "virtual fingertip" and to shape it by deforming it via a virtual tool. When touching the surface, various types of force effects are generated, such as hardness or friction. In addition, a sound is generated that conveys additional data about the current point of contact based on its elevation. The virtual fingertip can also be used as a deformation tool to change the shape of the surface, which acts like a rubber skin. (CISE)



A 3-D surface (terrain) model, the color indicates elevation and pitch: blue = low to red = high. *Credit: Chris Harding, Virtual Reality Applications Center, Iowa State University.*

► **Computational Discovery of Boron Nitride Nanotubes as Water Channels:** Development of bio-inspired devices is of critical importance towards developing next generation sensors, computing elements, drug discovery, bio-batteries and many other applications. Because of their superior electrical, mechanical, thermal, and chemical properties, carbon nanotubes are being investigated to create biomimetic sensors and water channels. Using advanced computational tools, researchers have shown that the water transport properties of boron nitride nanotubes (BNNTs) can be superior to those of carbon nanotubes. These results take us one step



Water permeation through a boron nitride nanotube (BNNT). The diameter of the BNNT is 6.9 Å and length of the BNNT nanotube is 14.2 Å. *Credit: N. R. Alura.*

closer towards realizing synthetic versions of aqua-porin water channels. Even though boron nitride nanotubes have been shown to possess many excellent physical properties, including thermal and mechanical properties, their water transport properties were previously unknown. (CCF)

SCIENCE AND ENGINEERING BEYOND MOORE'S LAW

Goal: Position the U.S. at the forefront of communications and computation capability beyond the physical and conceptual limitations of current technologies.

Description and Scientific Rationale: Moore's Law refers to the empirical observation made in 1965 that computer processing power, based on semiconductor integrated circuits, doubles about every 18 months. With current silicon technology, the physical and conceptual limits of Moore's Law are likely to be reached in 10 to 20 years. To take computing power and communications *beyond* Moore's Law requires entirely new scientific, engineering, and conceptual frameworks. Fundamental research across many disciplines will lead to the new hardware, architectures, algorithms, and software needed to address challenges such as efficient input and output, data storage and internal communications, and reduction of energy dissipation, as well as sheer computing power.

Science and Engineering Beyond Moore's Law (SEBML) is a multidisciplinary research investment with strong ties to economic competitiveness and potential for transformation. Tied to nanotechnology, computer science, materials science, and physics, it builds on past NSF investments in these areas and energizes them with new directions and challenges. Connections to the communications and computer industries ensure that SEBML will directly address the American Competitiveness Initiative (ACI) and America COMPETES Act. SEBML research will also enhance NSF investments in both the National Nanotechnology Initiative (NNI) and Networking and Information Technology Research and Development (NITRD).

Potential for Impact: Fundamental research will focus on a number of areas, including:

- New materials, devices, and processes that exploit the capability to create and manipulate specific quantum states. Some possible candidates include optical and photonic systems, spin-based or single-electron transistors, atom condensates, non-equilibrium devices, and molecular-based approaches including biologically inspired systems.
- New architectures, including and especially multi-core processors, with new control principles, massive parallelism, and designed asynchronicity and indeterminacy. Advances here may be applicable to other kinds of communication, distribution, and computing systems, leading to truly transformational outcomes.
- New algorithms that exploit hardware and architecture characteristics to optimize computing power, including those that exploit quantum interactions. The consideration of biological and social systems may lead to new approaches.
- New software that allows the effective use of new devices. New programming models will be needed, along with the languages and compilers that support them. Tools for analyzing, monitoring, debugging, and documenting software on these parallel and distributed systems will be essential.

Integration of Research and Education: SEBML has the potential to take computing and communications to new levels of capability, making development of a workforce trained in these new areas particularly important. All activities will seek creative ways to engage students and, as appropriate, take new ideas into formal and informal learning environments.

Leveraging Collaborations: NSF has in place proven partnerships among its directorates, connections with other communities (notably other governmental funding organizations and industry), and collaborations with international partners. NSF's effective and proven funding mechanisms of individual investigator, group, center, facilities, and instrumentation awards are well suited to the interdisciplinary approach required to tackle this complex problem. Strong potential exists for interagency partnering with organizations such as Department of Defense, NASA, NIST, and the intelligence community.

Urgency and Readiness: Maintaining global competitiveness requires faster, more efficient computing power. As discussed above, physical and conceptual limits of computing power are likely to be hit within the next 20 years. The Nation needs to start the development of the next generation of materials, algorithms, architectures, and software now to ensure competitiveness into the future. NSF leadership for NNI and NITRD has helped to create communities ready to take on the challenges of the future. SEBML will build on these past activities, leading them in important new directions.

Evaluation and Management: While it may be 10 to 20 years before the full impact of the investment will be known, indicators of success will be developed and monitored along the way. Indicators of a growing capability to conduct research in SEBML include increased numbers of students involved in SEBML projects and related data on breadth/diversity of participation, degree completion, opportunities to participate in interdisciplinary teaming, and movement to higher levels of education or first professional jobs; increased numbers of researchers involved in SEBML projects; numbers of collaborative projects that reach across disciplines or institutions; increased partnerships with national laboratories and private sector organizations; and the development of curricular materials or informal education activities that convey aspects of SEBML research. Indicators of research progress include highlights demonstrating progress from NSF awards; publications and patents resulting from NSF awards in SEBML; and public or private sector adoption of ideas from NSF awards in developing new technologies that stimulate innovation.

Principal Investigators and others active in SEBML will meet regularly. As a formal solicitation is developed, external contractors will be engaged to assist with design of data collection instruments and development of evaluation processes. Committees of Visitors and other external review panels involving all sectors of the economy will be involved in creating the evaluation of progress on SEBML research and education.

Funding: MPS funding includes SEBML as an area of emphasis in FY 2008. In FY 2009, the requested level of $20.0 million will allow NSF to create a truly coherent program across the Foundation with the funding to encourage transformational activities as well as creating partnering opportunities with the private sector and national laboratories to accelerate innovation.

SELECTED CROSSCUTTING PROGRAMS

NSF crosscutting programs include interdisciplinary programs and programs that are supported by multiple directorates. Examples of major crosscutting activities include the following:

ADVANCE: A budget of $20.79 million for ADVANCE in FY 2009, a decrease of $560,000 below the FY 2008 Estimate, will fund transformative efforts to address the systemic barriers to women's full participation in academic science and engineering (S&E). Included in the portfolio will be evaluation and assessment efforts to capture the impact of prior ADVANCE awards and to build upon effective practices, the dissemination and adaptation of models and strategies that have demonstrated effectiveness, as well as new awards for Institutional Transformation. In order to include a variety of institutional types, new catalytic awards (IT-Start) will be made to support basic data collection and analysis functions necessary to understand the status of women faculty in academic S&E at institutions seeking to promote organizational and cultural changes designed to produce increased recruitment, retention, and promotion of women in academic STEM fields. This category of award is intended to broaden the spectrum of institutions participating in ADVANCE activities, including primarily undergraduate institutions, teaching intensive colleges, community colleges, minority-serving institutions (e.g. tribal colleges, Historically Black Colleges and Universities, Hispanic Serving Institutions) and women's colleges.

Faculty Early Career Development (CAREER): The FY 2009 Request provides $181.91 million for CAREER, an increase of $14.15 million over the FY 2008 Estimate of $167.76 million. This will result in approximately 34 more CAREER awards than in FY 2008. CAREER awards support exceptionally promising college and university junior faculty who are committed to the integration of research and education and who are most likely to become the academic leaders of the 21st century.

Graduate Fellowships and Traineeships: The FY 2009 Request provides $245.86 million, an increase of $31.57 million over the FY 2008 Estimate, for NSF's three flagship graduate fellowship and traineeship programs. This funding will enable NSF to support an estimated 5,450 graduate students. This is an increase of 770 students over FY 2008.

- $124.76 million for the Graduate Research Fellowship (GRF) program, an increase of $28.60 million over the FY 2008 Estimate, will support graduate students in all STEM fields. Funding will support an estimated 3,075 fellows. GRF is widely recognized as a unique fellowship grant program because it supports the broad array of science and engineering disciplines across all fields as well as international research activity. In FY 2007, NSF received thousands of applications for these highly prestigious and competitive awards and was able to support only 2,656 fellows. The FY 2009 Request for GRF is significantly increased to provide opportunities for more U.S. citizens, nationals, and permanent resident aliens.

- $63.79 million for the Integrative Graduate Education and Research Traineeship (IGERT) program, an increase of $970,000 above the FY 2008 Estimate, will support comprehensive Ph.D. programs that are innovative models for interdisciplinary education and research and that prepare students for academic and non-academic careers. Funding will support an estimated 1,425 IGERT trainees. Additional funds for this program are well justified. Abt Associates, Inc. prepared an evaluation of the initial impacts of IGERT in February 2006 and concluded that "the IGERT program has been successful in achieving its goal of improving graduate educational programs in science and engineering….It has also begun to achieve its goal of catalyzing a cultural change in American graduate education…"

- $57.31 million for the Graduate Teaching Fellowships in K-12 Education (GK-12) program, an increase of $2.0 million above the FY 2008 Estimate, will strengthen partnerships between higher education institutions and local school districts by providing universities the opportunity to become engaged with a program that features outreach to K-12 schools in a manner that benefits both their teachers and students. Preliminary evaluative findings conducted in 2005 by AIR Associates, indicate that GK-12 is meeting its goal of enabling graduate students in STEM disciplines to acquire additional skills that will prepare them for professional and scientific careers. GK-12 fellows interact with teachers in K-12 schools, improving communication and teaching skills while enriching STEM instruction in K-12 schools. In 2007, the program engaged Abt Associates, Inc. in the development of a thorough evaluation of the program to provide data related to the success of GK-12. Funding will support an estimated 950 graduate fellows.

Long-Term Ecological Research (LTER): The FY 2009 Request provides $25.09 million, an increase of $230,000 above the FY 2008 Estimate. LTER supports fundamental ecological research that requires long time periods and large spatial scales. This program supports a coordinated network of more than two dozen field sites that focus on: 1) understanding ecological phenomena that occur over long temporal and broad spatial scales; 2) creating a legacy of well-designed and documented ecological experiments; 3) conducting major syntheses and theoretical efforts; and 4) providing information necessary for the identification and solution of environmental problems. LTER field sites represent a diversity of habitats in continental North America, the Caribbean, Pacific Ocean, and the Antarctic, including coral reefs, deserts, estuaries, lakes, prairies, various forests, alpine and Arctic tundra, urban areas and production agriculture.

Research Experiences for Teachers: (RET): The FY 2009 Request for NSF's RET program totals $9.69 million, an increase of $850,000 above the FY 2008 Estimate of $8.84 million. Funding will provide pre-service and in-service K-12 teachers with discovery-based learning experiences.

Research Experiences for Undergraduates (REU): The FY 2009 Request for NSF's REU program totals $61.55 million, an increase of $3.82 million above the FY 2008 Estimate of $57.73 million. The increase proposed for FY 2009 is consistent with the recent (July 2006) external evaluation of REU by SRI International. It found that undergraduate students who participate in hands-on research are more likely to pursue advanced degrees and careers in science, technology, engineering and mathematics (STEM) fields. REU supplements support active research participation by undergraduate students in any area of research funded by the NSF by providing supplements to research grants. REU sites involve students in research who might not otherwise have the opportunity, particularly those from institutions where research programs are limited. A significant fraction of the student participants come from outside the host institutions. Some REU grants have been extended to the freshman and sophomore levels to enhance retention and graduation rates. In FY 2009 efforts will be made to create partnerships between community colleges and baccalaureate degree granting institutions to provide research opportunities for community college STEM students and faculty.

Research in Undergraduate Institutions (RUI): The FY 2009 Request for NSF's RUI program totals $35.23 million, an increase of $3.70 million above the FY 2008 Estimate of $31.53 million. The RUI activity supports research by faculty members of predominantly undergraduate institutions through the funding of (1) individual and collaborative research projects, (2) the purchase of shared-use research instrumentation, and (3) Research Opportunity Awards (see above) for work with NSF-supported investigators at other institutions.

Science and Technology Centers (STCs): The FY 2009 Request for the Science and Technology Centers program totals $76.02 million, an increase of $11.07 million above the FY 2008 Estimate of $64.95 million. For additional information, see the NSF Centers Programs section of this chapter.

PERFORMANCE INFORMATION

This chapter provides supporting information on the performance goals that underpin NSF's FY 2009 Request and incorporates the agency's Government Performance and Results Act (GPRA) performance results for FY 2007. This integration of programmatic performance results with the agency's budget request enables the Foundation to demonstrate its leadership in incorporating the outcomes of its investments in discovery, innovation, and education in planning future directions to meet the opportunities and challenges in today's dynamic environment.

NSF's leadership in advancing the frontiers of science and engineering research and education is monitored through internal and external performance assessments. The results of this performance assessment process provide our stakeholders, including the American taxpayer, with vital information about the return on NSF's investments.

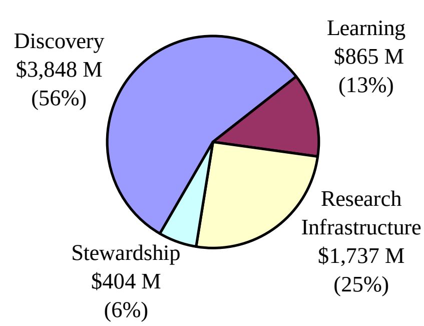
This chapter includes a discussion of the R&D Investment Criteria, NSF's strategic framework, NSF's performance assessment process, NSF's data verification and validation review, and the results of NSF's FY 2007 performance goals and their implications for FY 2008 and FY 2009. The following table summarizes the FY 2009 funding requirements for NSF's strategic outcome goals.

National Science Foundation
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Discovery	$3,200.60	$3,263.83	$3,847.98	$584.15	17.9%
Learning	785.00	808.82	864.98	56.16	6.9%
Research Infrastructure	1,578.70	1,633.30	1,736.85	103.55	6.3%
Stewardship	320.07	359.05	404.29	45.24	12.6%
Total, NSF	$5,884.37	$6,065.00	$6,854.10	$789.10	13.0%

Totals may not add due to rounding.

NSF's FY 2009 Request by Strategic Goal



R&D INVESTMENT CRITERIA

For NSF and other federal agencies with significant R&D portfolios, assessment activities are required to draw upon the R&D Investment Criteria established by the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP). These three criteria – Relevance, Quality, and Performance – are reflected in each of the directorate and office narratives throughout this budget request.

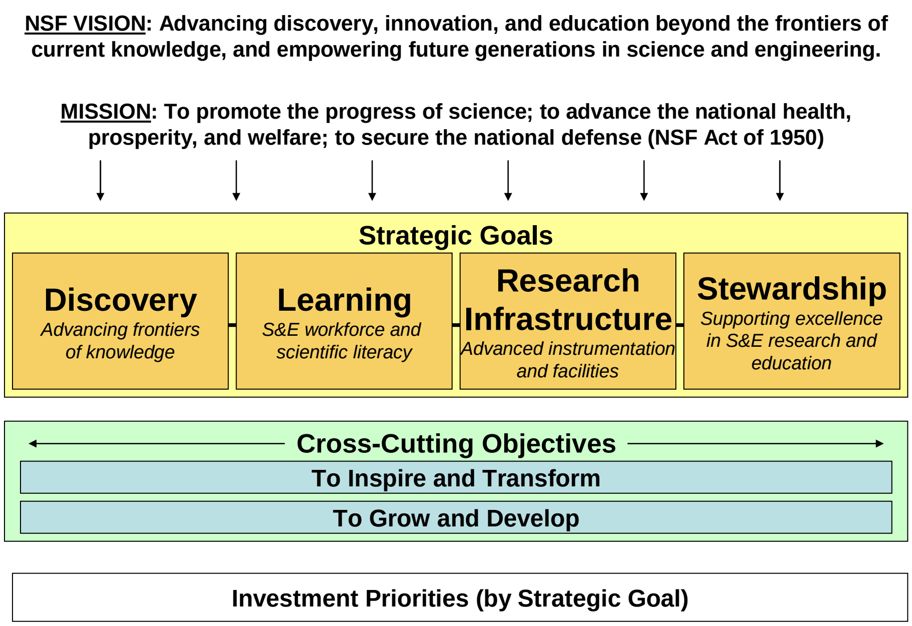
R& D Investment Criteria

- Relevance: R&D programs must be able to articulate why this investment is important, relevant, and appropriate.
- Quality: R&D programs must justify how funds will be allocated to ensure quality R&D.
- Performance: R&D programs must be able to monitor and document how well the investment is performing.

A detailed discussion of NSF's application of the R&D Criteria may be found in the Overview.

STRATEGIC FRAMEWORK

The NSF Strategic Plan for FY 2006 – 2011 (www.nsf.gov/pubs/2006/nsf0648/nsf0648.jsp) provides the framework for the agency's activities and performance goals, shown in the following chart.



To accomplish the NSF mission, "to promote the progress of science and engineering; to advance the national health, prosperity, and welfare; to secure the national defense" (NSF Act of 1950), NSF invests in the best ideas generated by scientists, engineers, and educators working at the frontiers of knowledge, and across all fields of research and education. The NSF Strategic Plan for FY 2006–FY 2011 established four long-term strategic outcome goals.

- *Discovery* – Foster research that will advance the frontiers of knowledge, emphasizing areas of greatest opportunity and potential benefit, and establishing the nation as a global leader in fundamental and transformational science and engineering.

- *Learning* – Cultivate a world-class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens.

- *Research Infrastructure* – Build the nation's research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure, and experimental tools.

- *Stewardship* -- Support excellence in science and engineering research and education through a capable and responsive organization.

The four interrelated outcome goals establish an integrated strategy to deliver new knowledge at the frontiers, meet vital national needs, and work to achieve the NSF vision. The first three goals – *Discovery, Learning,* and *Research Infrastructure* – focus on the Foundation's long-term investments in science and engineering research and education and align directly with the three strategic priorities established by the *National Science Board 2020 Vision for the National Science Foundation*. The fourth goal – *Stewardship* – is an internally-focused goal that emphasizes effective and efficient management practices. NSF also monitors 20 annual performance goals that were developed in conjunction with NSF's annual Program Assessment Rating Tool (PART) reviews.

NSF'S PERFORMANCE ASSESSMENT PROCESS

GPRA requires federal agencies to develop a strategic plan, establish annual performance goals, and report annually on the progress made toward achieving these goals. GPRA and PART pose a challenge to agencies like NSF involved in long-term science and education research. It is often not possible to link outcomes to annual investments because results in basic research and education can be unpredictable. Serendipitous results can be the most interesting and most important. Science and engineering research projects can generate discoveries in an unrelated area, and it can take years to recognize discoveries and their impact.

Assessing the impact of advances in science and engineering is inherently retrospective and is best performed using the qualitative judgment of experts. The use of external experts to review results and outcomes is a longstanding practice in the academic research and education community. NSF's use of such panels, such as the Committees of Visitors (COVs) and Advisory Committees, pre-dates GPRA and has been recognized as a valid quality assessment practice by the General Accountability Office (GAO) and others.

NSF has used external expert review for its programs for more than 20 years. Experts conduct independent assessments of the quality and integrity of our programs. On broader issues, NSF often uses external third parties such as the National Academies for outside review. The Foundation also convenes external panels of experts for special studies. A schedule of NSF's COV program evaluations and a list of the external evaluations completed in FY 2007 may be found on NSF's performance website: www.nsf.gov/about/performance/.

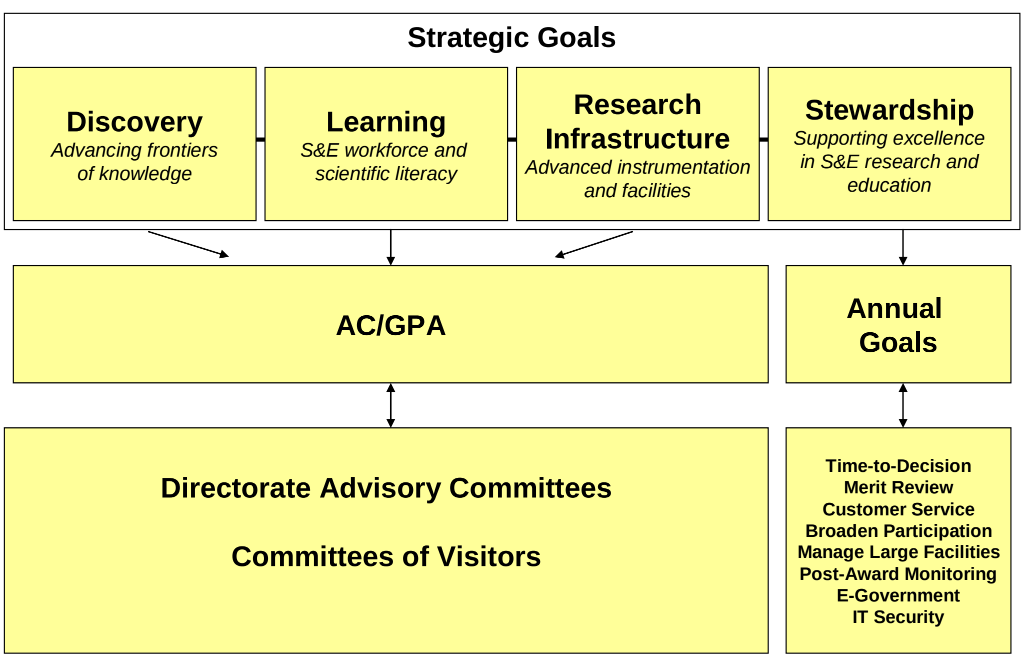
The value of expert review was affirmed in the 2001 report from the Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. According to the report, "Because we do not know how to measure knowledge while it is being generated and when its practical use cannot be predicted, the best we can do is ask experts in the field – a process called *expert review* – to evaluate research regularly while it is in progress. These experts, supplemented by quantitative methods, can determine whether the knowledge being generated is of high quality, whether it is directed to subjects of potential importance of the mission of the sponsoring agency, and whether it is at the forefront of existing knowledge – and therefore likely to advance the understanding of the field." (See: National Academy of Sciences, Committee on Science, Engineering, and Public Policy, *Implementing the Government Performance and Results Act for Research: A Status Report,* Washington, D.C., National Academy Press, 2001.)

OMB's approval of an alternative format for NSF performance assessment allowed NSF to develop a multilayer assessment approach, integrating quantitative metrics and qualitative reviews. The Advisory Committee for GPRA Performance Assessment (AC/GPA), composed of experts from various disciplines and fields of science, engineering, mathematics, and education, provides advice and recommendations to the NSF Director regarding NSF's performance under GPRA. As the reporting and determination of results for performance goals are inherently governmental functions, NSF makes the final determination on achievement using AC/GPA findings as one critical input.

The AC/GPA met on June 14-15, 2007, to review more than 1,100 outstanding accomplishments – or "highlights" – compiled by NSF program officers. In addition, the AC/GPA had access to all award abstracts, investigator project reports, and COV reports to give a full picture of the NSF portfolio. Moreover, the process of assessment by NSF's external advisory committee is itself assessed by an independent, external management consulting firm. A more detailed discussion of the verification and validation of GPRA and PART data appears later in this chapter.

NSF's Performance Assessment Framework is depicted in the following chart.

NSF Performance Assessment Framework



Advisory Committee for GPRA Performance Assessment (AC/GPA): The AC/GPA was established in June 2002 to provide advice and recommendations to the NSF Director regarding NSF's performance under GPRA. NSF is the only federal agency that invites an external advisory committee to perform an analysis of its entire portfolio as part of the agency GPRA assessment process. The Committee, which is composed of about 20 scientists, engineers, and educators, reviews NSF's investments in research and education to determine NSF's annual progress towards meeting its strategic outcome goals of Discovery, Learning, and Research Infrastructure. The AC/GPA's assessment of whether NSF has demonstrated significant achievement is based on the collective experience and expertise of the Committee following the review of more than 1,100 outstanding accomplishments ("highlights") written by NSF program officers. The AC/GPA submits a report annually to the Director that evaluates NSF performance under each strategic goal. NSF's annual independent verification and validation report includes a review of the AC/GPA assessment process.

In FY 2007, the AC/GPA recommended several steps to improve the Committee's process for reviewing and selecting program highlights and other material in preparation for determining significant achievement under the three strategic outcome goals. Those recommendations called for establishing evaluation criteria and making process improvements in the collecting and writing of program "highlights." In response to those recommendations, NSF has established specific evaluation criteria under each of the three goals that the Committee will use in 2008. To address the recommendation on process improvements, NSF has designed a framework in which the "highlights" will be categorized in order to assure broad program coverage. NSF will provide all relevant performance information to the AC/GPA members in order to provide the other types of data and information requested by the Committee in its FY 2007 recommendations.

Advisory Committees: Each directorate and office has an Advisory Committee that meets twice a year to provide guidance on priorities, address program effectiveness, and review COV reports and management's response to COV recommendations. Advisory Committees are chartered and hence subject to Federal Advisory Committee Act rules. Each division or crosscutting program has a COV that meets once every three years to review and assess program priorities, program management, and award accomplishments or outcomes. COV recommendations must be addressed by the appropriate division director, and appropriate actions must be taken to comply.

Committees of Visitors (COVs): NSF's Committees of Visitors provide program assessments that are used both in program management and in annual GPRA reporting. Each COV typically consists of up to 20 external experts who review one or more programs over a two to three day period. A program may be defined as one or more divisions within a directorate or office, or a crosscutting program. The external experts are selected to ensure independence, programmatic coverage, and geographic balance, and they represent academia, industry, government, and the public sector. Approximately one-third of NSF activities are assessed each year. In evaluating the results of NSF investments, COVs are asked to comment on program activities as they relate to NSF's strategic outcome goals, justify their findings, and provide supporting examples or statements. COVs are subcommittees of NSF directorate advisory committees. Each COV prepares a report and the division or program that is being reviewed must prepare a response. COV reports, along with the NSF responses to their recommendations, are submitted to the parent advisory committee and to the Director of NSF. All COV reports and NSF responses are public documents posted on NSF's website at: www.nsf.gov/od/oia/activities/cov/covs.jsp.

Project-level Assessment During Merit Review

While Advisory Committees and Committees of Visitors assess NSF programs at the portfolio level, assessment at the project or award level is conducted in two different ways. First, when submitting a proposal, applicants provide information on the results of previous NSF support. Such information is available to external experts who review the proposals based on NSF's merit review criteria. Program officers also review this information and take it into account when making recommendations on awards or declines. Second, awardees are required to submit annual progress reports during the course of their awards. Such information is required before funds are released each year for continuing grants.

The merit review process involves several steps. When a proposal arrives at NSF, a program officer or team of program officers reviews the proposal and assigns it to at least three experts from outside NSF. Reviews are generally conducted by mail, in a review panel, or by combination of mail and review panel. Mail reviewers and panelists use two general criteria: intellectual merit and broader impacts. Following merit review, the program officer makes a recommendation to award or decline the proposal, taking into account external reviews, panel discussion, and other factors such as portfolio balance and the availability of funding. The division director reviews and approves the recommendation. If an award is recommended, grants officers perform an administrative review. Large awards are also subject to further review at a higher level, by the Director's Review Board and the National Science Board.

PART Assessments

In 2002, OMB developed the Program Assessment Rating Tool (PART) as a systematic methodology for assessing the performance of program activities across the federal government. A PART evaluation focuses on program purpose and design, strategic planning, program management, and program results and accountability. Each year, about 20 percent of an agency's programs undergo PART review. To date, all of NSF's programs have undergone PART review. Of the more than 1,000 PART programs that have been evaluated across federal agencies, 18 percent have received the highest rating of "Effective". NSF PART evaluations conducted to date have all received an "Effective" rating. PART results are available at www.whitehouse.gov/omb/expectmore/index.html.

Types and Sources of Performance Data and Information

Most of the data that underlie achievement assessments for the strategic outcome goals originate outside the agency and are submitted to NSF through the Project Reporting System, which includes annual and final project reports for all awards. Through this system, performance information and data are available to program staff, third party evaluators, and other external committees.

- Information on *Discovery:* Published and disseminated results, including journal publications, books, software, audio or video products; contributions within and across disciplines; organizations of participants and collaborators (including collaborations with industry); contributions to other disciplines, infrastructure, and beyond science and engineering; use beyond the research group of specific products, instruments, and equipment resulting from NSF awards; and role of NSF-sponsored activities in stimulating innovation and policy development.

- Information on *Learning:* Student, teacher, and faculty participants in NSF activities; demographics of participants; descriptions of student involvement; education and outreach activities under grants; demographics of science and engineering students and workforce; numbers and quality of educational models, products and practices used/developed; number and quality of teachers trained; and student outcomes including enrollments in mathematics and science courses, retention, achievement, and science and mathematics degrees received.

- Information on *Research Infrastructure:* Published and disseminated results; new tools and technologies; multidisciplinary databases; software, newly-developed instrumentation and other inventions; data, samples, specimens, germ lines, and related products of awards placed in shared repositories; facilities construction and upgrade costs and schedules; and operating efficiency of major multi-user facilities.

Most of the data supporting the annual quantitative performance goals may be found in NSF's central systems. These central systems include the Enterprise Information System; FastLane, with its Project Reporting System and its Facilities Performance Reporting System; the Program Information Management System (PIMS); the Proposal and Reviewer System; the Awards System; the Electronic Jacket; and the Financial Accounting System. These systems are subject to regular checks for accuracy and reliability.

Data/Information Limitations

With respect to the strategic outcome goals, the AC/GPA has access to recent Committee of Visitor reports and program assessments conducted by external programmatic expert panels, principal investigator project reports, and award abstracts. Because it is impractical for an external committee to review the contributions to the performance goals by each of the more than 20,000 active awards, NSF program officers provided the Committee with more than 1,100 summaries of notable results in FY 2007. Collections obtained from expert sampling of these outcomes, or program highlights, from awards, together with COV reports and project reports, form the primary basis for the AC/GPA determination of whether NSF demonstrated significant achievement in the strategic outcome goals of *Discovery, Learning,* and *Research Infrastructure*. The approach to highlights collection is a type of non-probabilistic sampling, commonly referred to as "judgmental" or "purposeful" sampling, which is best designed to identify notable examples and outcomes resulting from NSF's investments. It is the aggregate of collections of notable examples and outcomes that can, on their own, demonstrate significant agency-wide achievement of the strategic goals. Nevertheless, the combination of COV reports, project reports, award abstracts, and notable accomplishments covers the entire NSF portfolio.

Data Verification and Validation

As in prior years, NSF engaged an independent, external consultant to conduct a validation and verification (V&V) review of its annual performance information and data. IBM Global Business Services (IBM) completed a V&V review of the performance data and information reported for all the FY 2007 goals except three *Stewardship* goals: Post-Award Monitoring, E-Government, and IT Security. These three goals were examined as part of NSF's FY 2007 Internal Controls review and it was determined that a second review by IBM would be redundant. For the strategic outcome goals, IBM reviewed the processes NSF used to obtain external assessment of its goals.

IBM's V&V review is based on guidelines issued by GAO that require federal agencies to provide confidence that the policies and procedures underlying performance reporting are complete, accurate, and consistent. (See *GAO Guide to Assessing Agency Annual Performance Plans,* GAO/GGD-10.1.20.) IBM assessed the validity of the data and reported results as well as verified the reliability of the methods used to collect, process, maintain, and report data. IBM also reviewed NSF's information systems based on GAO standards for application controls.

FY 2007 SUMMARY PERFORMANCE RESULTS

The tables below summarize the results of the Foundation's GPRA goals from FY 2003 through FY 2007. In FY 2007, NSF achieved 100 percent of its strategic outcome goals and 70 percent of its annual PART performance goals. In FY 2007, the Stewardship Goal contained eight performance areas, each of which had specific qualitative milestones and/or quantitative measures. Detailed information for each goal follows.

FY 2003 – FY 2007 Strategic Outcome Goal Results

Strategic Outcome Goal	**FY 2003**	**FY 2004**	**FY 2005**	**FY 2006**	**FY 2007**
Discovery	G	G	G	G	G
Learning	G	G	G	G	G
Research Infrastructure	G	G	G	G	G
Stewardship[1]	G	G	G	G	G

Green (G) indicates successful achievement

[1] The Stewardship strategic outcome goal is an expansion of NSF's prior year Organizational Excellence goal. For FY 2007, eight targets and milestones were developed for the Stewardship goal (see pages 16-17).

FY 2003 – FY 2007 Annual PART Performance Goals
Number and Percent of Goals Achieved

	FY 2003	**FY 2004**	**FY 2005**	**FY 2006**	**FY 2007**
Annual Performance Goals	10 of 16 (63%)	23 of 26 (88%)	14 of 17 (82%)	15 of 22 (68%)	14 of 20 (70%)

STRATEGIC OUTCOME GOAL 1: DISCOVERY

Foster research that will advance the frontiers of knowledge, emphasizing areas of greatest opportunity and potential benefit, and establishing the Nation as a global leader in fundamental and transformational science and engineering.

FY 2003–FY 2007 Performance Results				
FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
G	G	G	G	G
Green (G) indicates successful achievement				

Investments in ***Discovery*** support cutting-edge research that yield new and important discoveries and promote the development of new knowledge and techniques within and across traditional boundaries. These investments enable NSF to meet its mission of promoting the progress of science while at the same time helping to maintain the Nation's capacity to excel in science and engineering, particularly in academic institutions. The results of NSF-funded research projects provide a rich foundation for broad and useful applications of knowledge and the development of new technologies. Support in this area also promotes the education and training of the next generation of scientists and engineers by providing them with an opportunity to participate in discovery-oriented projects.

Method of Assessment: NSF convenes an external expert group, the Advisory Committee for GPRA Performance Assessment (AC/GPA) to evaluate the outcomes reported under this goal.

FY 2007 Result: NSF achieved this goal.

Implications for FY 2008 and FY 2009: This goal is a continuation of NSF's previous goal of *Ideas*, originally established in FY 2001. The AC/GPA determined that NSF was successful in achieving the *Ideas* Goal in Fiscal Years 2003 through 2006, and its successor, the *Discovery* goal, in FY 2007. This goal will be continued in FY 2008 and FY 2009. NSF will use the external advisory committee to determine achievement of this goal.

Resources Required for FY 2009: Successful achievement of this goal is dependent on NSF receiving the resources outlined below.

Support of Discovery Goal by Appropriation

(Dollars in Millions)

	R&RA	EHR	MREFC	AOAM	OIG	Total
Discovery	$3,670.27	$177.71	-	-	-	$3,847.98

Means and Strategies for Success: NSF's ongoing portfolio of investments and continuing priorities are outlined in this budget submission. In addition, the following long-term investment priorities associated with the strategic goal of *Discovery*, have been identified for increased emphasis or additional funding during the period of the Strategic Plan, FY 2006-2011:

- Promote transformational, multidisciplinary research.
- Investigate the human and social dimensions of new knowledge and technology.

- Further U.S. economic competitiveness through basic research that can lead to new, valuable, and marketable technologies.
- Foster research that improves our ability for sustainable living on Earth.
- Advance fundamental research in computational science and engineering, and in fundamental, applied, and interdisciplinary mathematics and statistics.

Additional Information:

Program Assessment Rating Tool (PART) Evaluations: Two PART evaluations were conducted between FY 2003 and FY 2006 on programs under *Discovery/Ideas*: the Fundamental Science and Engineering Program and the Science and Engineering Centers Program. Both were rated "Effective."

Comments from the Advisory Committee for GPRA Performance Assessment (AC/GPA):

*The Committee concluded that there has been **significant achievement** in the Discovery outcome goal. The Committee found that the National Science Foundation has fulfilled its strategic goal of Discovery and is doing so with research that encompasses ever-more complex systems of technological and societal relevance.*

Many exciting discoveries were described and the project outcomes provided clear examples of goal achievement. Most of the highlights were found to be exemplars of the NSF research investment and did capture uniformly interesting scientific research. The highlights consistently underscored the success the NSF has achieved in freeing their grantees from "one-flavor" research and encouraging them in their proposals to explore scientific problems that cross multiple scientific disciplines. Many of the projects have significant broader impacts components, including opportunities for underrepresented groups in science and engineering, and pre-college and college students. (Page 11, www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf07207.)

STRATEGIC OUTCOME GOAL 2: LEARNING

Cultivate a world-class, broadly inclusive science and engineering workforce,
and expand the scientific literacy of all citizens.

FY 2003–FY 2007 Performance Results				
FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
G	G	G	G	G
Green (G) indicates successful achievement				

Leadership in today's knowledge economy requires world-class scientists and engineers and a national workforce that is scientifically, technically, and mathematically strong. Investments in ***Learning*** aim to improve the quality and reach of science, engineering, and mathematics education and enhance student achievement. Each year, NSF supports an estimated 240,000 people – teachers, students, and researchers at every educational level and across all disciplines in science and engineering. Embedded in all NSF programs are efforts to build a more inclusive, knowledgeable, and globally-engaged workforce that fully reflects the strength of the Nation's diverse population. Because science and engineering increasingly address global questions of significant societal importance, today's research requires globally-engaged investigators working collaboratively across agencies and international organizations to apply the results of research to long-standing global challenges.

Method of Assessment: NSF convenes an external expert group, the Advisory Committee for GPRA Performance Assessment (AC/GPA) to evaluate the outcomes reported under this goal.

FY 2007 Result: NSF achieved this goal.

Implications for FY 2008 and FY 2009: This goal is a continuation of NSF's previous goal of *People*, originally established in FY 2001. The AC/GPA determined that NSF was successful in achieving the *People* Goal in fiscal years 2003 through 2006, and its successor, the *Learning* goal, in FY 2007. This goal will be continued in FY 2008 and FY 2009. NSF will use the external advisory committee to determine achievement of this goal.

Resources Required for FY 2009: Successful achievement of this goal is dependent on NSF receiving the resources outlined below.

Support of Learning Goal by Appropriation

(Dollars in Millions)

	R&RA	EHR	MREFC	AOAM	OIG	Total
Learning	$280.10	$584.88	-	-	-	$864.98

Means and Strategies for Success: NSF's ongoing portfolio of investments and continuing priorities are outlined in this budget submission. In addition, the following long-term investment priorities, associated with NSF's Strategic Outcome Goal of *Learning*, have been identified for increased emphasis or additional funding during 2006-2011.

- Build strong foundations and foster innovation to improve K-12 teaching, learning, and evaluation in science and mathematics.
- Advance the fundamental knowledge base on learning, spanning a broad spectrum from humans to animals and machines.
- Develop methods to effectively bridge critical junctures in STEM education pathways.
- Prepare a diverse, globally-engaged STEM workforce.
- Integrate research with education, and build capacity.
- Engage and inform the public in science and engineering through informal education.

Additional Information:

Program Assessment Rating Tool (PART) Evaluations: Four PART evaluations were conducted based between FY 2003 and FY 2006 on programs under *Learning/People*: Support for Individual Researchers; Small Research Collaborations; Support for Research Institutions; and Capability Enhancement of Researchers, Institutions, and Small Businesses. All were rated "Effective."

Comments from the Advisory Committee for GPRA Performance Assessment (AC/GPA):

*The Committee concluded that there has been **significant achievement** in the Learning strategic outcome goal.*

The spectrum of funded projects analyzed by the Committee shows that the portfolio of the NSF provides meaningful opportunities for educators, students, and the general public to engage in the many facets of science and technology. Several projects address broadening access to science and engineering education and target the challenges faced by groups historically underrepresented in STEM challenges. Also included are descriptions of excellent efforts to address the needs of students with limited mobility, hearing impairment, or sight impairment. In some instances projects are designed to result in better understanding of how all people learn, while addressing the specific challenges faced by a target population. To that end, not only are traditional classroom strategies being revisited, with much needed effort being expended in teacher training, but students are also being exposed to research activities as early as possible in the curriculum. Finally, public resources such as museums are being leveraged in new ways to enhance learning while drawing the attention of and engaging the general public.

The Committee finds that the highlights provide compelling - but not always complete - evidence that projects funded advance a variety of approaches to the cultivation of a science and engineering workforce that can compete in a global environment. Many projects are also expanding the scientific literacy of all citizens. (Page 12, www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf07207.)

STRATEGIC OUTCOME GOAL 3: RESEARCH INFRASTRUCTURE

Build the Nation's research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure, and experimental tools.

FY 2003–FY 2007 Performance Results				
FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
G	G	G	G	G
Green (G) indicates successful achievement				

NSF investments in ***Research Infrastructure*** provide state-of-the-art tools for research and education, such as multi-user research facilities, distributed instrumentation networks and arrays, accelerators, telescopes, research vessels, aircraft, and earthquake simulators. In addition, investments in internet-based and distributed user facilities are increasing as a result of rapid advances in computer, information, and communication technologies. NSF support for large multi-user facilities helps create state-of-the-art, world-class research platforms vital to new discoveries and the progress of research. NSF support may include construction, upgrades, operations, maintenance, and personnel needed to assist scientists and engineers in the conduct of research at such facilities. NSF consults with other agencies and international partners to avoid duplication and optimize capabilities for U.S. researchers.

Method of Assessment: NSF convenes an external expert group, the Advisory Committee for GPRA Performance Assessment (AC/GPA) to evaluate the outcomes reported under this goal.

FY 2007 Result: NSF achieved this goal.

Implications for FY 2008 and FY 2009: This goal is a continuation of NSF's previous goal of *Tools*, originally established in FY 2001. The AC/GPA determined that NSF was successful in achieving the *Tools g*oal in fiscal years 2003 through 2006, and its successor, the *Research Infrastructure* goal, in FY 2007. This goal will be continued in FY 2008 and FY 2009. NSF will use the external advisory committee to determine achievement of this goal

Resources Required for FY 2009: Successful achievement of this goal is dependent on NSF receiving the resources outlined below.

Support of Research Infrastructure Goal by Appropriation

(Dollars in Millions)

	R&RA	EHR	MREFC	AOAM	OIG	Total
Research Infrastructure	$1,573.35	$15.99	$147.51	-	-	$1,736.85

Means and Strategies for Success: NSF's ongoing portfolio of investments and continuing priorities are outlined in this budget submission. In addition, the following long-term investment priorities, associated with the strategic goal of Research Infrastructure, have been identified for increased emphasis or additional funding during the period of the Strategic Plan, FY 2006-2011:

- Fill the gaps in our ability to provide enabling research.
- Identify and support the next generation of large research facilities.
- Develop a comprehensive, integrated cyberinfrastructure to drive discovery in all fields of science and engineering.
- Strengthen the Nation's collaborative advantage by developing unique networks and innovative partnerships.

Additional Information:

Program Assessment Rating Tool (PART) Evaluations: Four PART evaluations were conducted based between FY 2003 and FY 2006 on programs under Research Infrastructure/Tools: Construction and Operations of Research Facilities; Polar Research Tools, Facilities, and Logistics; Federally Funded Research and Development Centers; and Investment in Research Infrastructure and Instrumentation. All were rated "effective."

Comments from the Advisory Committee for GPRA Performance Assessment (AC/GPA):

The Committee concluded that there has been ***significant achievement*** *for the Research Infrastructure outcome goal.*

As the issues researchers face increasingly involve phenomena at or beyond the limits of our measurement capabilities, their study requires the use of new generations of powerful research infrastructure. NSF investments provide state-of-the-art infrastructure for research and education, such as distributed instrumentation networks and arrays, multi-user facilities, digital libraries, accelerators, telescopes, research vessels, aircraft, and earthquake simulators. In addition, funding devoted to the Research Infrastructure strategic outcome goal provides resources needed to support large surveys and databases as well as computational and computing infrastructures for all fields of science, engineering, and education.

NSF provides support for large multi-user facilities that meet the need for state-of-the-art, world-class research platforms vital to new discoveries and the progress of research. NSF support may include construction, upgrades, operations, maintenance, and personnel needed to assist scientists and engineers in the conduct of research at such facilities. NSF consults with other agencies and international partners to avoid duplication and optimize capabilities for American researchers.

Many of the Research Infrastructure projects would not have been possible had it not been for the previously funded and enabling research infrastructure or cyberinfrastructure, upon which they depended.

There is no doubt that access to cyberinfrastructure of the highest level will allow for complex simulations and visualizations to take place. The infrastructure and the simulations they produce may not be transformative, but may be a means to an end. However, some of these simulations are allowing scientists to use computations as a new method of investigation - acquiring insights that would be impossible using experiments or theory alone. For example, using cyberinfrastructure for early diagnosis of brain disorders that transform treatment and care for millions, simulating turbulent flow in narrowed human arteries could lead to new treatments, and simulating the formation of the universe could lead to new fundamental insights. (Page 15, www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf07207)

STRATEGIC OUTCOME GOAL 4: STEWARDSHIP

Support excellence in science and engineering research and education
through a capable and responsive organization.

The ***Stewardship*** strategic outcome goal is fundamental to NSF's leadership in achieving success through its investments in science, engineering, and education research. With the implementation of the new Strategic Plan at the beginning of FY 2007, the Foundation set priorities for program and management staff. As a result, the Foundation established eight annual *Stewardship* performance areas for FY 2007 aimed to support the agency's focus on promoting continuous performance improvement.

Method of Assessment: Program or administrative units throughout the Foundation assumed leadership for achieving specific targets/milestones under Stewardship.

FY 2007 Result: FY 2007 results are shown on pp. 16-17. NSF's performance under Stewardship is successful when, in the aggregate, results reported demonstrate significant achievement in the majority of the performance areas.

Implications for FY 2008 and FY 2009: This goal is an update of NSF's prior years' *Organizational Excellence* goal. The AC/GPA determined that NSF was successful in achieving the *Organizational Excellence g*oal in fiscal years 2003 through FY 2006. For FY 2007, the *Organizational Excellence* goal was updated as the *Stewardship* goal, which is comprised of eight performance areas with targets and milestones that determine achievement. This goal will be continued in FY 2008 and FY 2009 with updated targets and milestones.

Resources Required for FY 2009: Successful achievement of this goal is dependent on NSF receiving the resources outlined below.

Support of Stewardship Goal by Appropriation

(Dollars in Millions)

	R&RA	EHR	MREFC	AOAM	NSB	OIG	Total
Stewardship	$70.27	$11.83	-	$305.06	$4.03	$13.10	$404.29

Means and Strategies for Success: The Foundation developed annual targets/milestones for *Stewardship* based on several of the long-term investment priorities in the Strategic Plan: improving the quality of the merit review process, improving customer service, broadening participation from underrepresented groups and diverse institutions, improving the management of large facilities, and improving the efficiency and effectiveness of administrative and management procedures. The FY 2007 results led to additions and revisions of the *Stewardship* targets and milestones for FY 2008 and beyond.

FY 2007 Stewardship Goal Results

1. Time-to-Decision	For 70 percent of proposals, inform applicants whether their proposals have been declined or recommended for funding within six months of deadline or target date or of receipt date, whichever is later.	FY 2007
2. Merit Review	Improve the transparency of decisions and the quality of the merit review process. NSF's performance is successful when results reported in FY 2007 indicate that a majority of the following milestones were achieved: • Develop methods or metrics to assess the transparency and quality of the merit review process. • Provide a written context statement to the Principal Investigator (PI) that describes the process by which the proposal was reviewed and the context of the decision (such as the number of proposals and awards, information about budget availability, and considerations in portfolio balancing). FY 2007 Target: 95 percent. FY 2007 Result: 95 percent • Develop a website to identify and disseminate effective merit review practices. • Ensure that the Program Management Seminar includes case studies on how to implement an effective merit review process. • Include a section on training and mentoring of program officers in the annual Merit Review Report to the National Science Board.	New in FY 2007
3. Customer Service	Improve customer service to the science, engineering, and education communities. NSF's performance is successful when results reported in FY 2007 indicate the following milestones were achieved: • Conduct a survey of investigators on the proposal submission and review processes, targeting those who have submitted proposals to NSF. Gather data on such factors as (1) drivers that increase proposal submissions, (2) PI perceptions regarding success rates, (3) impacts on the PI and reviewer community of increasing proposal submission rates, and (4) trends in customer satisfaction. • Analyze the survey results for directions in improving customer service in order to implement selected recommendations in FY 2008.	New in FY 2007

4. Broaden Participation	Expand efforts to increase participation by underrepresented groups and diverse institutions throughout the United States in all NSF activities and programs. NSF's performance is successful when results reported in FY 2007 indicate the following milestones were achieved: • Develop a plan to increase participation in NSF programs by underrepresented groups, which includes defining existing baseline data. • Develop a plan to broaden the pool of reviewers for NSF proposals.	New in FY 2007
5. Management of Large Facilities	Ensure the efficient and effective management of the construction and operation of large facilities. NSF's performance is successful when results reported in FY 2007 indicate the following milestones were achieved: • For construction projects funded by the Major Research Equipment and Facilities Construction appropriation, keep negative cost and schedule variance to less than 10 percent. *[Note: The Scientific Ocean Drilling Vessel (SODV) did not achieve its construction schedule; NSF program staff will continue to work with the project managers to monitor the SODV construction schedule.]* • For facilities in the operational phase, keep operating time lost to less than 10 percent for 90 percent of those facilities.	Revised in FY 2007
6. Post-Award Monitoring	Fully implement NSF's program of post-award financial and administrative monitoring, in order to test the risk-based identification model against the mitigation strategy of increasing methods of oversight. NSF's performance is successful when results reported in FY 2007 indicate the following milestones were achieved: • Apply the risk assessment results in order to develop the FY 2007 monitoring plan (on-site visits, desk reviews, and Financial Cash Transaction Report (FCTR) sampling efforts). • Complete 95 percent of projected FY 2007 on-site monitoring visits by the end of FY 2007. • Complete 95 percent of projected FY 2007 desk reviews by the end of FY 2007. • Complete 95 percent of projected FY 2007 FCTR transaction testing by the end of FY 2007.	New in FY 2007

7. E-Government	Establish an E-Government Implementation Plan. NSF's performance is successful when results reported in FY 2007 indicate the following milestones were achieved: • Achieve 90 percent of major E-Government Plan implementation milestones. • Post 100 percent of discretionary grants applications on Grants.gov as specified in NSF Ramp-Up Plan.	New in FY 2007 ●
8. Information Technology (IT) Security	Conduct a successful Federal Information Security Management Act IT Program Review. NSF's performance is successful when results reported in FY 2007 indicate a majority of the following milestones were achieved: • Ensure major applications and general support systems certification and accreditations are current and up to date. • Ensure that 96 percent or more of IT systems are installed in accordance with security configurations. • Ensure that 90 percent or more of applicable systems have Privacy Impact Assessments.	New in FY 2007 ●

● Indicates successful achievement.
□ Indicates partial achievement.

ANNUAL PART PERFORMANCE MEASURES

In addition to reporting the results of the eight performance areas under the Stewardship strategic outcome goal, the Foundation is reporting the results of 20 PART performance goals that were established during the PART assessments of ten Foundation programs during the period FY 2003 through FY 2006. Those PART assessments and performance goals were based on an alignment of programs under the NSF Strategic Plan for FY 2003–2008. With the adoption of a new Strategic Plan for FY 2006–2011, the Foundation has incorporated some of the PART performance goals into the Stewardship goal (such as time-to-decision and management of large facilities), which are important Foundation-wide management issues.

FY 2007 Results: Detailed results of the PART performance goals for FY 2007 are published on NSF's Performance Website: www.nsf.gov/about/performance/. The following table summarizes the results of the PART performance goals in three major categories: Time-to-Decision, Broadening Participation, and Management of Large Facilities. Time-to-Decision is reported in four separate PART program categories (Research Grants, Education Grants, the Major Research Instrumentation Program, and NSF Science and Engineering Centers). Broadening Participation includes efforts to increase the participation in NSF activities and programs of underrepresented groups, diverse institutions, and small businesses, and increase the number of graduate students in three flagship programs: the Graduate Research Fellowship Program (GRF), the Integrative Graduate Education and Research Traineeship (IGERT) Program, and the Graduate Teaching Fellows in K-12 Education (GK-12) Program. Management of Large Facilities includes the construction and operations of NSF-supported major multi-user research facilities, including the Federally Funded Research and Development Centers (FFRDCs) and the construction and logistical support for Polar facilities. Also included under Facilities are goals relating to the number of users of the TeraGrid, which is an open scientific discovery infrastructure at 11 partner sites around the United States that forms an integrated, persistent computational resource; the number of users of National Center for Atmospheric Research (NCAR) datasets; and the percent of observing time awarded through competitive merit review at the National Optical Astronomy Observatory (NOAO).

NSF was successful in achieving performance targets for 14 of the 20 annual PART goals for a success ratio of 70 percent. The unmet targets were in the Broadening Participation and Management of Large Facilities performance areas. Explanations for the unmet targets are included in the following table. In the Broadening Participation area, NSF is actively developing a plan to increase participation among underrepresented individuals and diverse institutions throughout the United States in all NSF activities and programs. In the Management of Large Facilities area, only one of the five facilities under construction did not meet the schedule goal. NSF continues to work with all facilities project managers to ensure that cost and schedule targets will be met and that the facilities operate at efficient levels. It may be said that in all the cases of unmet targets, the performance goal was set at an approximate target level, and the deviation from that level is slight. There was no effect on overall program or activity performance.

Implications for FY 2008 and FY 2009: NSF continues to place great value on its ability to make recommendations on the funding of proposals and conveying those recommendations to principal investigators in a timely manner. The overall, Foundation-wide goal of making those recommendations within six months for 70 percent of all proposals submitted to the Foundation will be continued. Although NSF will continue to monitor the time-to-decision for the PART program areas, the Foundation will not report those results in its FY 2008 and FY 2009 performance report. Likewise, in the Broadening Participation area, NSF has established several new performance measures that were recommended by a Foundation-wide staff working group and, consequently, will no longer report the results of the eight

PART performance goals in that area. In the area of Management of Large Facilities, NSF will report on the facilities construction and operations goals under Stewardship.

On the following pages are a list of the FY 2007 Annual PART Performance Goals, with indications of whether the goal was achieved or not, and a summary table of the goals organized into the three categories described above.

Summary Results of FY 2007 Annual PART Performance Goals

TIME -TO-DECISION	
1. Research Grants: Time to Decision	●
2. Education Grants: Time to Decision	●
3. Major Research Instrumentation (MRI) Program: Time to Decision	●
4. Science and Engineering Centers: Time to Decision for Pre-Proposals	●
BROADENING PARTICIPATION	
5. Research Grants: Percentage of Proposals from Outside the Top 100 Institutions	●
6. Education Grants: Percentage of Proposals from Outside the Top 100 Institutions	■
7. Major Research Instrumentation (MRI) Program: Percentage of Proposals from Outside the Top 100 Institutions	●
8. CAREER Program: Number of Applicants from Minority-Serving Institutions	●
9. Graduate Research Fellowship Program: Number of Applicants from Underrepresented Groups	●
10. SBIR/STTR Programs: Percentage of Phase I Awards to New PIs	■
11. Science and Engineering Centers: Percentage of Non-Academic Partner Institutions	■
12. GRF, IGERT, GK-12 Programs: Number of Graduate Students Funded	■
MANAGEMENT OF LARGE FACILITIES	
13. MREFC Facilities: Construction Cost and Schedule	■
14. Major Multi-User Research Facilities: Operations	●
15. FFRDC Operational Facilities	■
16. National Optical Astronomy Observatory (NOAO): Observing Time	●
17. National Center for Atmospheric Research (NCAR): Number of Users of Datasets	●
18. TeraGrid Users	●
19. Polar Programs: Support for Research in the Antarctic	●
20. Polar Programs: Construction Cost and Schedule	●

● Goal Achieved
■ Goal Not Achieved

Detailed Results of FY2007 Annual PART Performance Goals

Time-to-Decision	For 70 percent of proposals submitted Foundation-wide, inform applicants within six months of receipt whether their proposals have been declined or recommended for funding.	
	1. Research Grants	
	2. Education Grants	
	3. Major Research Instrumentation Program	
	4. S&E Centers Programs For 85 percent of pre-proposals submitted, inform applicants about funding decisions within six months of proposal receipt or deadline, or target date, whichever is later, while maintaining a credible and efficient merit review system.	
Broadening Participation	Increase the percentage of proposals from academic institutions not in the top 100 of NSF funding recipients.	
	5. Research Grants	
	6. Education Grants *Explanation for Unmet Goal*: The performance goal was set at an approximate target level, and the deviation from that level is slight. There was no effect on overall program performance.	
	7. Major Research Instrumentation Program	
	8. CAREER Program Increase the number of applicants for Faculty Early Career Development (CAREER) awards from investigators at Minority Serving Institutions.	

	9. Graduate Research Fellowships Program Increase the number of applicants to the Graduate Research Fellowship Program from groups that are underrepresented in the science and engineering workforce.	●
	10. SBIR/STTR Programs Maintain a high percentage of awards to new principal investigators (companies) in Phase I of the Small Business Innovation Research (SBIR) and Small Business Technology Research (STTR) Programs. *Explanation for Unmet Goal*: Although the performance goal was set at an approximate target level and the deviation from that level is slight, NSF will continue its outreach efforts, especially among small businesses owned and operated by women and members of underrepresented groups.	■
	11. Science and Engineering Centers Program For all NSF Centers, maintain a high percentage of partner institutions that are non-academic institutions (includes industry, state, local, and other Federal agencies). *Explanation for Unmet Goal*: The performance goal was set at an approximate target level, and the deviation from that level is slight.	■
	12. GRF, IGERT, GK-12 Programs Increase the number of graduate students funded through fellowships or traineeships in the Graduate Research Fellowship (GRF) Program, the Integrative Graduate Education and Research Traineeships Program (IGERT), and the Graduate Teaching Fellows in K-12 Education (GK-12) Program. *Explanation for Unmet Goal*: Funding decreased, resulting in fewer numbers of fellowships and traineeships being awarded.	■

Management of Large Facilities		
	13. MREFC Facilities For all facilities in the Major Research Equipment and Facilities Construction (MREFC) account, keep negative cost and schedule variances to less than 10 percent. *Explanation for Unmet Goal*: One project, the Scientific Ocean Drilling Vessel (SODV), did not achieve the schedule goal. SODV schedule variance is principally due to delays associated with the main shipyard contract, the cumulative effect of which has resulted in behind schedule performance of the required outfitting, steel structure repairs, and piping, electrical, and HVAC systems installation.	■
	14. Major Multi-User Research Facilities For 90 percent of NSF facilities in the operational phase, keep operating time lost due to unscheduled downtime to less than ten percent.	●
	15. FFRDC Operational Facilities For 90 percent of NSF's Federally Funded Research and Development Centers (FFRDCs), keep operating time lost to less than ten percent. *Explanation for Unmet Goal*: One of the four FFRDCs, the National Astronomy and Ionosphere Center (NAIC) did not achieve the goal for two reasons: (1) the NAIC Arecibo telescope is undergoing major maintenance, and (2) as a result of the recommendations of the NSF Astronomy Division Senior Review, NAIC operations funding was reduced by 24 percent, leading to a commensurate reduction in observing hours available for scientific research programs.	■
	16. NOAO Observing Time At least 95 percent of the operating time at the National Optical Astronomy Observatory (NOAO) should be allocated through the NOAO allocation committee.	●
	17. NCAR Dataset Users Increase the number of unique users of datasets at the National Center for Atmospheric Research (NCAR).	●

	18. TeraGrid Users Increase the number of unique users of the TeraGrid from among the science, engineering, and education community.	●
	19. Polar Programs: Support for Research in the Antarctic Provide the necessary research support for researchers in the Antarctic at least 90 percent of the time they are scheduled to perform research.	●
	20. Polar Programs: Construction Cost and Schedule Keep the percent of cost and schedule variances for major Polar projects, as monitored by Earned Value Management, to seven percent or less.	●

● Goal achieved.
■ Goal not achieved.

TECHNICAL INFORMATION

FY 2009 Appropriations Language

National Science Foundation

RESEARCH AND RELATED ACTIVITIES

For necessary expenses in carrying out the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-1875), and the Act to establish a National Medal of Science (42 U.S.C. 1880-1881); services as authorized by 5 U.S.C. 3109; maintenance and operation of aircraft and purchase of flight services for research support; acquisition of aircraft; and authorized travel; $5,593,990,000, to remain available until September 30, 2010, of which not to exceed $540,000,000 shall remain available until expended for polar research and operations support, and for reimbursement to other Federal agencies for operational and science support and logistical and other related activities for the United States Antarctic program: *Provided* That, from funds specified in the fiscal year 2009 budget request for icebreaking services, up to $54,000,000 shall be available for the procurement of polar icebreaking services: *Provided further*, That the National Science Foundation shall only reimburse the Coast Guard for such sums as are agreed to according to the existing memorandum of agreement: *Provided further*, That receipts for scientific support services and materials furnished by the National Research Centers and other National Science Foundation supported research facilities may be credited to this appropriation.

EDUCATION AND HUMAN RESOURCES

For necessary expenses in carrying out science and engineering education and human resources programs and activities pursuant to the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-1875), including services as authorized by 5 U.S.C. 3109, authorized travel and rental of conference rooms in the District of Columbia, $790,410,000, to remain available until September 30, 2010.

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

For necessary expenses for the acquisition, construction, commissioning, and upgrading of major research equipment, facilities, and other such capital assets pursuant to the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-1875), including authorized travel, $147,510,000, to remain available until expended: Provided, That funds may be utilized for design, subject to the approval of the Director of the National Science Foundation in consultation with the National Science Board.

AGENCY OPERATIONS AND AWARD MANAGEMENT

For agency operations and award management necessary in carrying out the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-1875); services authorized by 5 U.S.C. 3109; hire of passenger motor vehicles; not to exceed $9,000 for official reception and representation expenses; uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; rental of conference rooms in the District of Columbia; and reimbursement of the Department of Homeland Security for security guard services; $305,060,000: *Provided*, That contracts may be entered into under this heading in fiscal year 2009 for maintenance and operation of facilities, and for other services, to be provided during the next fiscal year.

OFFICE OF INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General as authorized by the Inspector General Act of 1978, as amended, $13,100,000, to remain available until September 30, 2010.

OFFICE OF THE NATIONAL SCIENCE BOARD

For necessary expenses (including payment of salaries, authorized travel, hire of passenger motor vehicles, the rental of conference rooms in the District of Columbia, and the employment of experts and consultants under section 3109 of title 5, United States Code) involved in carrying out section 4 of the National Science Foundation Act of 1950, as amended (42 U.S.C 1863) and Public Law 86-209 (42 U.S.C. 1880 et seq.), $4,030,000: *Provided*, That not more than $2,500 shall be available for official reception and representation expenses.

SUMMARY OF FY 2009 BUDGETARY RESOURCES BY APPROPRIATION

(DOLLARS IN MILLIONS)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	CHANGE OVER FY 2008 Estimate Amount	Percent
RESEARCH AND RELATED ACTIVITIES					
Appropriation	$4,665.95	$4,821.47	$5,593.99	772.52	16.0%
Unobligated Balance Available Start of Year	3.94	22.63			
Unobligated Balance Available End of Year	-22.63				
Unobligated Balance Rescission P.L. 110-161	-	-17.17			
Adjustments to Prior Year Accounts[1]	3.61				
EPSCoR adjustment[2]	102.11				
Subtotal, R&RA	$4,752.98	$4,826.93	$5,593.99	$767.06	15.9%
Transferred from other funds[3]	5.46	-	-		
Total Budgetary Resources	$4,758.44	$4,826.93	$5,593.99	$767.06	15.9%
EDUCATION AND HUMAN RESOURCES [3]					
Appropriation	$796.69	$725.60	$790.41	$64.81	8.9%
Unobligated Balance Available Start of Year	0.13	0.10			
Unobligated Balance Available End of Year	-0.10				
Unobligated Balance Rescission P.L. 110-161	-	-0.10			
Adjustments to Prior Year Accounts[1]	1.04				
EPSCoR adjustment[2]	-102.11				
Total Budgetary Resources	$695.65	$725.60	$790.41	$64.81	8.9%
MAJOR RESEARCH EQUIPMENT & FACILITIES CONSTRUCTION					
Appropriation	$190.88	$220.74	$147.51	-$73.23	-33.2%
Unobligated Balance Available Start of Year	2.78	27.60			
Unobligated Balance Available End of Year	-27.60				
Unobligated Balance Rescission P.L. 110-161	-	-15.27			
Adjustments to Prior Year Accounts[1]	0.15				
Total Budgetary Resources	$166.21	$233.07	$147.51	-$85.56	-36.7%
AGENCY OPERATIONS AND AWARD MANAGEMENT					
Appropriation	$248.25	$281.79	$305.06	$23.27	8.3%
Unobligated Balance Available Start of Year	-				
Unobligated Balance Available End of Year	-				
Unobligated Balance Rescission P.L. 110-161	-				
Adjustments to Prior Year Accounts[1]	-0.01				
Subtotal, AOAM	$248.24	$281.79	$305.06	$23.27	8.3%
Transferred from other funds[5]	0.25				
Total Budgetary Resources	$248.49	$281.79	$305.06	$23.27	8.3%

Totals may not add due to rounding.

[1] Adjustments include expired balances, and upward and downward adjustments to prior year obligations.

[2] In FY 2008 EPSCoR was transferred from the EHR activity to Integrative Activities and is shown here for all years for comparability.

[3] In FY 2007 $5.46 million was transferred to NSF by the U.S. Department of State for an award to the U.S. Civilian Research and Development Foundation.

[4] Excludes $145.94 million in obligations in FY 2007 and an estimated $100.0 million in FY 2008 and FY 2009 receipts from H-1B Nonimmigrant Petitioner Fees.

[5] The FY 2007 Actual includes a transfer of $250,000 from the Department of State for processing an award to the U.S. Civilian Research and Development Foundation.

SUMMARY OF FY 2009 BUDGETARY RESOURCES BY APPROPRIATION

(DOLLARS IN MILLIONS)

	FY 2007	FY 2008	FY 2009	CHANGE OVER FY 2008 Estimate	
	Actual	Estimate	Request	Amount	Percent
NATIONAL SCIENCE BOARD					
Appropriation	$3.97	$3.97	$4.03	$0.06	1.5%
Unobligated Balance Available Start of Year	-				
Unobligated Balance Available End of Year	-				
Unobligated Balance Rescission P.L. 110-161	-				
Adjustments to Prior Year Accounts[1]	-0.32				
Total Budgetary Resources	$3.65	$3.97	$4.03	$0.06	1.5%
OFFICE OF INSPECTOR GENERAL					
Appropriation	$11.43	$11.43	$13.10	$1.67	14.6%
Unobligated Balance Available Start of Year	1.01	0.71			
Unobligated Balance Available End of Year	-0.71				
Unobligated Balance Rescission P.L. 110-161	-	-0.46			
Adjustments to Prior Year Accounts[1]	0.19				
Total Budgetary Resources	$11.92	$11.68	$13.10	$1.42	12.2%
TOTAL DISCRETIONARY, NATIONAL SCIENCE FOUNDATION	$5,884.37	$6,083.04	$6,854.10	$771.06	12.7%
EDUCATION AND HUMAN RESOURCES, H-1B					
Appropriation, Mandatory	$107.36	$100.00	$100.00	-	0.0%
Unobligated Balance Available Start of Year	98.19	63.37			
Unobligated Balance Available End of Year	-63.37				
Unobligated Balance Rescission P.L. 110-161	-				
Adjustments to Prior Year Accounts[1]	3.76				
Total Budgetary Resources	$145.94	$163.37	$100.00	-$63.37	-38.8%
TOTAL, NATIONAL SCIENCE FOUNDATION	$6,030.31	$6,246.41	$6,954.10	$707.69	11.3%

Totals may not add due to rounding.

[1] Adjustments include expired balances, and upward and downward adjustments to prior year obligations.

NSF FY 2009 FUNDING BY PROGRAM

(Dollars in Millions)

PROGRAM	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change Over FY 2008 Estimate Amount	Change Over FY 2008 Estimate Percent
BIOLOGICAL SCIENCES					
MOLECULAR AND CELLULAR BIOSCIENCES	$111.50	$112.51	$126.10	$13.59	12.1%
INTEGRATIVE ORGANISMAL SYSTEMS	202.31	199.86	216.27	16.41	8.2%
ENVIRONMENTAL BIOLOGY	109.60	110.86	125.64	14.78	13.3%
BIOLOGICAL INFRASTRUCTURE	80.23	86.94	86.99	0.05	0.1%
Research Resources	*48.22*	*55.61*	*55.66*	*0.05*	*0.1%*
Human Resources	*32.01*	*31.33*	*31.33*	*-*	*0.0%*
EMERGING FRONTIERS	104.90	101.85	120.06	18.21	17.9%
Total, BIO	$608.54	$612.02	$675.06	$63.04	10.3%
COMPUTER AND INFORMATION SCIENCE AND ENGINEERING					
COMPUTING & COMMUNICATION FOUNDATIONS	$122.76	$143.45	$180.01	$36.56	25.5%
COMPUTER & NETWORK SYSTEMS	162.77	173.91	206.91	33.00	19.0%
INFORMATION & INTELLIGENT SYSTEMS	119.25	138.93	173.60	34.67	25.0%
INFORMATION TECHNOLOGY RESEARCH	121.89	78.24	78.24	0.00	0.0%
Total, CISE	$526.68	$534.53	$638.76	$104.23	19.5%
ENGINEERING					
CHEMICAL, BIOENGINEERING, ENVIRONMENTAL & TRANSPORT SYSTEMS	$128.27	$131.00	$173.34	$42.34	32.3%
CIVIL, MECHANICAL & MANUFACTURING INNOVATION	157.30	159.81	201.88	42.07	26.3%
ELECTRICAL, COMMUNICATIONS & CYBER SYSTEMS	83.24	83.50	94.36	10.86	13.0%
INDUSTRIAL INNOVATION & PARTNERSHIPS	120.78	121.67	140.90	19.23	15.8%
SBIR/STTR	[108.67]	[109.37]	[127.00]	[17.63]	[16.1%]
ENGINEERING EDUCATION & CENTERS	115.16	115.89	119.85	3.96	3.4%
EMERGING FRONTIERS IN RESEARCH & INNOVATION	25.25	25.00	29.00	4.00	16.0%
Total, ENG	$629.99	$636.87	$759.33	$122.46	19.2%

NSF FUNDING BY PROGRAM

(Dollars in Millions)

PROGRAM	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change Over FY 2008 Estimate Amount	Percent
GEOSCIENCES					
ATMOSPHERIC SCIENCES	$227.44	$229.30	$260.58	$31.28	13.6%
Atmospheric Sciences Research Support	*142.32*	*142.88*	*165.16*	*22.28*	*15.6%*
National Center for Atmospheric Research	*85.12*	*86.42*	*95.42*	*9.00*	*10.4%*
EARTH SCIENCES	152.83	156.08	177.73	21.65	13.9%
Earth Sciences Project Support	*117.66*	*120.90*	*139.57*	*18.67*	*15.4%*
Instrumentation and Facilities	*35.17*	*35.18*	*38.16*	$2.98	8.5%
INNOVATIVE & COLLABORATIVE EDUCATION AND RESEARCH	56.82	56.82	56.82	-	-
OCEAN SCIENCES	308.76	310.46	353.54	43.08	13.9%
Ocean Section	*115.64*	*115.64*	*130.70*	*15.06*	*13.0%*
Integrative Programs Section	*112.54*	*112.54*	*128.54*	*16.00*	*14.2%*
Marine Geosciences Section	*80.58*	*82.28*	*94.30*	*12.02*	*14.6%*
Total, GEO	$745.85	$752.66	$848.67	$96.01	12.8%
MATHEMATICAL AND PHYSICAL SCIENCES					
ASTRONOMICAL SCIENCES	$215.39	$217.86	$250.01	$32.15	14.8%
CHEMISTRY	191.22	194.22	244.67	50.45	26.0%
MATERIALS RESEARCH	257.27	260.22	324.59	64.37	24.7%
MATHEMATICAL SCIENCES	205.74	211.79	245.70	33.91	16.0%
PHYSICS	248.47	250.52	297.70	47.18	18.8%
MULTIDISCIPLINARY ACTIVITIES	32.64	32.70	40.00	7.30	22.3%
Total, MPS	$1,150.73	$1,167.31	$1,402.67	$235.36	20.2%
SOCIAL, BEHAVIORAL AND ECONOMIC SCIENCES					
SOCIAL AND ECONOMIC SCIENCES	$99.86	$100.42	$107.49	$7.07	7.0%
BEHAVIORAL AND COGNITIVE SCIENCES	84.64	84.63	92.78	8.15	9.6%
SCIENCE RESOURCES STATISTICS	30.04	30.08	33.21	3.13	10.4%
Total, SBE	$214.54	$215.13	$233.48	$18.35	8.5%

NSF FUNDING BY PROGRAM

(Dollars in Millions)

PROGRAM	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change Over FY 2008 Estimate Amount	Change Over FY 2008 Estimate Percent
OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING	$40.36	$41.34	$47.44	$6.10	14.8%
OFFICE OF CYBERINFRASTRUCTURE	$182.42	$185.33	$220.08	$34.75	18.8%
OFFICE OF POLAR PROGRAMS					
ARCTIC SCIENCES	$89.27	$90.85	$103.97	$13.12	14.4%
ANTARCTIC SCIENCES	56.65	60.35	71.24	10.89	18.0%
ANTARCTIC INFRASTRUCTURE & LOGISTICS	233.76	228.36	255.02	26.66	11.7%
U.S. Antarctic Logistical Support Activities	[67.52]	[67.52]	[67.52]	-	-
POLAR ENVIROMENT, SAFETY & HEALTH	5.79	5.98	6.74	0.76	12.7%
USCG POLAR ICEBREAKING	52.96	57.00	54.00	-3.00	-5.3%
Total, OPP	$438.43	$442.54	$490.97	$48.43	10.9%
INTEGRATIVE ACTIVITIES[1]	$219.45	$232.27	$276.00	$43.73	18.8%
EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCoR)	[102.11]	[111.10]	[113.50]	[2.00]	[2.2%]
COMMUNICATING SCIENCE BROADLY	-	-	{4.00}	-	-
U.S. ARCTIC RESEARCH COMMISSION	$1.45	$1.47	$1.53	$0.06	4.1%
Total, RESEARCH AND RELATED ACTIVITIES	$4,758.44	$4,821.47	$5,593.99	$772.52	16.0%
EDUCATION AND HUMAN RESOURCES					
RESEARCH ON LEARNING IN FORMAL AND INFORMAL SETTINGS	$208.99	$214.00	$226.50	$12.50	5.8%
UNDERGRADUATE EDUCATION	204.96	211.05	219.83	8.78	4.2%
Curriculum, Laboratory and Instructional Development [2]	*84.41*	*83.45*	*85.41*	*1.96*	*2.3%*
Workforce Development [2]	*74.60*	*79.10*	*83.42*	*4.32*	*5.5%*
Math and Science Partnership	*45.95*	*48.50*	*51.00*	2.50	5.2%
GRADUATE EDUCATION	155.90	160.10	190.70	30.60	19.1%
HUMAN RESOURCE DEVELOPMENT	125.80	140.45	153.38	12.93	9.2%
Undergraduate/Graduate Student Support	*76.36*	*83.35*	*86.85*	3.50	4.2%
Research & Education Infrastructure	*34.11*	*40.35*	*47.28*	*6.93*	*17.2%*
Opportunities for Women and Persons with Disabilities	*15.33*	*16.75*	*19.25*	2.50	14.9%
Total, EHR[3]	$695.65	$725.60	$790.41	$64.81	8.9%

1 In FY 2008 EPSCoR was transferred from the EHR activity to Integrative Activities and is shown here for all years for comparability.

2 The Robert Noyce Teacher Scholarship program is included in the Workforce Development line. NSF proposes to move this program from the Curriculum, Laboratory and Instructional Development line as of FY 2008 in order to better align with the program's purpose.

3 Excludes $145.94 million in obligations in FY 2007 and an estimated $100.0 million in FY 2008 and FY 2009 receipts from H-1B Nonimmigrant Petitioner Fees.

NSF FUNDING BY PROGRAM

(Dollars in Millions)

PROGRAM	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change Over FY 2008 Estimate Amount	Change Over FY 2008 Estimate Percent
MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION	$166.21	$220.74	$147.51	-$73.23	-33.2%
AGENCY OPERATIONS AND AWARD MANAGEMENT[4]	$248.49	$281.79	$305.06	$23.27	8.3%
NATIONAL SCIENCE BOARD	$3.65	$3.97	$4.03	$0.06	1.5%
OFFICE OF INSPECTOR GENERAL	$11.92	$11.43	$13.10	$1.67	14.6%
NATIONAL SCIENCE FOUNDATION	$5,884.37	$6,065.00	$6,854.10	$789.10	13.0%

Totals may not add due to rounding.

[4]The FY 2007 Actual inlcudes a transfer of $250,000 from the U.S. Department of State for processing an award to the U.S. Civilian Research and Development Foundation.

OBJECT CLASSIFICATION
NSF Consolidated Obligations
(Dollars in Millions)

Object Class Code	Standard Title	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
11.1	Full-time permanent	$121	$132	$142
11.3	Other than fulltime permanent	12	12	12
11.5	Other personnel compensation	6	6	7
11.8	Special personal service payment	-	1	2
	Total personnel compensation	$139	$151	$163
12.1	Civilian personnel benefits	32	38	39
21.0	Travel and transportation of persons	22	25	26
23.1	Rental payments to GSA	22	24	25
23.3	Communications, utilities, and miscellaneous charges	5	1	1
25.1	Advisory and assistance services[1]	107	80	86
25.2	Other services	15	14	18
25.3	Purchases of goods and services from Government accounts	11	13	14
25.4	Operation and maintenance of facilities	36	36	36
25.5	Research and development contracts	52	52	52
25.6	Medical Care	-	1	1
25.7	Operation and maintenance of equipment[1]	-	28	34
26.0	Supplies and materials	2	3	3
31.0	Equipment[1]	4	15	12
41.0	Grants, subsidies, and contributions	5,437	5,584	6,344
	Total, Direct obligations [2]	$5,884	$6,065	$6,854

Totals may not add due to rounding.

[1]In FY 2008 and 2009 IT contracts in object class 25.1 are reclassified as 25.7 and 31.0.

[2]Excludes obligations for the Donations, H-1B Nonimmigrant Petitioners, and reimbursable accounts.

REIMBURSABLE ACTIVITY

Reimbursements for the Research and Related Activities Appropriation and the Education and Human Resources Appropriation are realized from other federal agencies that have entered into interagency agreements with the Foundation. NSF enters into agreements (including Memoranda of Understanding) with other U.S. government agencies, as authorized by the NSF Act, 42 U.S.C. 1870 (c) and the Economy Act: 31 U.S.C. 1535, under which NSF assumes some responsibility for activities supported by these agencies. These activities can include jointly funded projects and programs, support of research operations and logistics, and access to NSF supported research facilities.

Reimbursements by Agency

(Dollars in Millions)

DEPARTMENT/AGENCY	FY 2007 Actual
DEFENSE	
Air Force	$12.8
Army	7.9
Other DOD (DARPA, NSA & Intelligence Agency)	14.3
Subtotal, DOD	$35.0
Interior	1.0
CIA	2.9
Commerce (Including NOAA)	4.4
Education	1.0
Energy	8.5
Environmental Protection Agency	1.0
State	1.0
Agriculture	2.4
Health & Human Services	22.6
Homeland Security	10.0
NASA	7.7
National Archives	1.8
Transportation	1.0
OTHER (less than $500,000)	1.1
TOTAL REIMBURSEMENTS	**$101.4**

Since the 1980s, the number of interagency agreements NSF handles has increased dramatically. This increase is indicative of the growth in the breadth and complexity of the Foundation's programmatic activity. Consistent with applicable legislation and GAO decisions, agreements include reimbursement for costs that are incurred in the management and administration of these awards.

In FY 2007 the largest portion of NSF's reimbursable activity came from joint activities with the Department of Defense (34.5 percent), the Department of Health and Human Services (22.3 percent), the Department of Homeland Security (9.9 percent), the Department of Energy (8.4 percent) and National Aeronautics and Space Administration (7.6 percent). Reimbursable activities with the Department of Defense were primarily for the management of the National Center for Atmospheric Research (NCAR). Reimbursable activities with the Department of Health and Human Services are for non-medical biological research such as the human frontiers science program and the Macromolecular Structure Database (MSD) program.

NSF Personnel Summary of Permanent Appointments

Statutory Pay Systems	FY 2007 Actual Appointments
ES	79
AD	318
GS/GM-15	82
GS/GM-14	115
GS/GM-13	111
GS-12	102
GS-11	72
GS-10	11
GS-9	84
GS-8	42
GS-7	80
GS-6	6
GS-5	4
GS-4	2
Subtotal, GS/GM	711
Total, Permanent Appointments	1,108
Average Salary	$102,398

All data are for permanent appointments.

EXPLANATION OF CARRYOVER FOR FY 2008 BY ACCOUNT

The National Science Foundation carried over a total unobligated balance of $114.41 million from the FY 2007 Appropriation ($51.04 million in discretionary funds and $63.37 million in mandatory funds). P.L. 110-161 requires the rescission of $33.0 million in discretionary funds and does not apply rescission against mandatory funds. The use for carryover funds is described below.

- Within the **Research and Related Activities (R&RA)** appropriation, $22.63 million was carried forward into FY 2008, of which $17.17 million is rescinded as required under P.L. 110-161.

  A total of $16.38 million was carried forward into FY 2008 for the *Science of Learning Centers (SLCs)*. This amount is rescinded as required under P.L. 110-161.

  The available balance of $5.46 million was carried forward by the Office of International Science and Engineering (OISE) for the *Civilian Research and Development Foundation (CRDF).*

  A total of $449,810 was carried forward into FY 2008 by the *Office of Polar Programs*. This amount is rescinded as required under P.L. 110-161.

  Unallotted funds totaling $333,926 were rescinded as required under P.L. 110-161.

- Within the **Education and Human Resources (EHR)** appropriation, a total of $99,331 was carried forward into FY 2008. This amount is rescinded as required under P.L. 110-161.

- Within the **Major Research Equipment and Facilities Construction (MREFC)** appropriation, a total of $27.60 million was carried forward into FY 2008, of which $15.27 million is rescinded as required under P.L. 110-161. The remaining $12.33 million of MREFC carryover will be applied to ongoing projects.

  A total of $5.12 million was carried forward into FY 2008 for the *Ocean Observatories Initiative* (OOI). This amount is rescinded as required under P.L. 110-161.

  A total of $4.0 million was carried forward into FY 2008 for the *National Ecological Observatory Network* (NEON). This amount is rescinded as required under P.L. 110-161.

  A total of $51,934 was carried forward into FY 2008 for the *Scientific Ocean Drilling Vessel* (SODV). This amount is rescinded as required under P.L. 110-161.

  South Pole Station Modernization carried forward a total of $3.08 million into FY 2008, of which $2.55 million is rescinded as required under P.L. 110-161. The remaining $531,375 will be applied toward the logistics and warehousing facility at South Pole, completion of exterior activities for the elevated station, and demolition of the existing station and other construction as the project approaches its scheduled completion in 2010.

  A total of $4.27 million was carried forward into FY 2008 for the *IceCube Neutrino Observatory* (IceCube), of which $3.53 million was rescinded as required under P.L. 110-161. The balance of $736,170 will be applied toward remaining construction items for IceCube as the project approaches its scheduled completion in 2010.

A total of $4.21 million was carried forward for remaining construction items for *EarthScope* as the project approaches its scheduled completion in 2008.

NSF obligated $2.58 million of the appropriated $9.43 million for the *Alaska Region Research Vessel* (ARRV) for updated engineering drawings and preparing the project execution plan, awarded during FY 2007. The remaining carryover of $6.85 million will be competed and awarded in FY 2008 and will include acquisition planning, shipyard contract award, design verification, and ordering of long lead equipment items.

Unallotted funds totaling $26,222 were rescinded as required under P.L. 110-161.

- Within the **Office of Inspector General (OIG)** appropriation, a total of $707,223 was carried forward into FY 2008 of which $457,308 is rescinded as required under P.L. 110-161. The remaining $249,915 will fund priority audits that are contracted out and the forensic analysis support required for some OIG investigations.

- Within the **H-1B Nonimmigrant Petitioner** account (Mandatory), $63.37 million was carried forward into FY 2008. The rescission in P.L. 110-161 does not apply to this mandatory account.

The H-1B funding at NSF support two primary programs, the ITEST program, and the S-STEM program. In FY 2007, NSF obligated $145.94 million in these two programs.

NSF's carryover into FY 2008 for H-1B funded programs is $63.37 million, $8.23 million in ITEST, $35.95 million in S-STEM, and $19.19 million in 4th Qtr. receipts (see below). This is a substantial improvement from the previous year, where the carryover was $98.19 million.

Distribution of FY 2007 Carryover into FY 2008

(Dollars in Millions)

	FY 2007 Carryover from FY 2006	FY 2008 Carryover from FY 2007	Rescission	Adjusted FY 2007 Carryover
Research and Related Activities	3.90	22.63	-17.17	5.46
Education and Human Resources	0.13	0.10	-0.10	-
Major Research Equipment and Facilities Construction	2.78	27.60	-15.27	12.33
Office of Inspector General	1.01	0.71	-0.46	0.25
Subtotal (Discretionary)	**7.82**	**51.04**	**-33.00**	**18.04**
H-1B Nonimmigrant Petitioner (Mandatory)	98.19	63.37	-	63.37
Total	**$106.01**	**$114.41**	**-$33.00**	**$81.41**

Totals may not add due to rounding.

FULL BUDGETARY COSTING

The tables below show two methods for allocating the full budgetary cost of the NSF FY 2009 Budget Request. The first shows the full budgetary costs allocated to each of NSF's operating directorates. The second shows these costs allocated to three of NSF's strategic outcome goals: Discovery, Learning, and Research Infrastructure. Stewardship, NSF's fourth strategic goal encompasses the indirect costs to be allocated under full budgetary costing. These allocations represent part of the process, using readily available information, by which NSF achieved the integration of budget, cost, and performance, consistent with the President's Management Agenda.

What is Full Budgetary Cost? OMB Circular A-11 defines "full-cost" as the sum of all budget resources used by an agency to achieve program outputs and outcomes. These include both *direct* program costs and *indirect* costs, which generally include administrative costs and other activities that are not directly attributable to a single program or activity. For two of NSF's appropriations, Research and Related Activities (R&RA) and Education and Human Resources (EHR), all funds are directly attributable to directorates and outcome goals. For NSF's other appropriations, Major Research Equipment and Facilities Construction (MREFC), Agency Operations and Award Management (AOAM), the National Science Board (NSB), and the Office of Inspector General (OIG) funds are distributed using the methodologies described below.

Allocation by Directorate

The current budget structure contains program activities within R&RA and EHR that equate to directorates. Therefore, R&RA and EHR funding is already aligned by directorate. MREFC funds projects that are managed by a particular NSF directorate. Therefore, each MREFC project can be directly associated with a particular directorate. In addition, each managing directorate is responsible for the initial planning, design, and follow-on operations and maintenance costs that are funded through R&RA. The MREFC program funds are assigned to the managing directorate responsible for oversight of a particular project. (Table 1)

All budget items funded through the AOAM, NSB, and OIG appropriations accounts are defined as Stewardship and are allocated to directorates. More than half of the AOAM account can be precisely associated with an individual directorate. These direct AOAM budget items consist of distributed funding for travel, training, equipment, supplies, incentive awards, and premium pay. Also, space rental and personnel compensation and benefits (PC&B) of employees in a particular directorate are attributed to that directorate in the financial accounting system.

Once direct AOAM budget items that are associated with a particular directorate have been assigned, then budget items associated with the Office of Information and Resource Management (IRM), Office of Budget, Finance and Award Management (BFA), the staff offices in the Office of the Director (OD), the NSB, and OIG are allocated. These indirect AOAM budget items are allocated to a particular directorate based on its proportion of the total FY 2009 Request. The FY 2009 NSB and OIG budgetary costs are assigned using the same methodology as the Indirect AOAM costs total. (Table 1)

Allocations by Strategic Outcome Goal

The full budgetary costing by Discovery, Learning, and Research Infrastructure was derived by using the same methodology as stated above, except the Direct AOAM budget items, Indirect AOAM budget items, and total NSB, and OIG funding were assigned using the strategic goal percentages for each directorate. (Table 2)

FY 2009 FULL BUDGETARY COSTING

Table 1: Allocation of Major Research Equipment and Facilities Construction (MREFC),
Agency Operations and Award Management (AOAM), National Science Board (NSB), and the Office of Inspector General (OIG)
(Dollars in Thousands)

FY 2009 Congressional Request	BIO	CISE	ENG	GEO	MPS	SBE	OCI	OISE	OPP	IA	SUBTOTAL	EHR	TOTAL
R&RA & EHR	**$675,060**	**$638,760**	**$759,330**	**$848,670**	**$1,402,670**	**$233,480**	**$220,080**	**$47,440**	**$492,500**	**$276,000**	**$5,593,990**	**$790,410**	**$6,384,400**
MREFC													
AdvLIGO					51,430						**$51,430**		**$51,430**
ALMA Construction					82,250						**$82,250**		**$82,250**
ARRV											-		-
ATST					2,500						**$2,500**		**$2,500**
EarthScope											-		-
HIAPER											-		-
IceCube Neutrino Observatory									11,330		**$11,330**		**$11,330**
NEES											-		-
NEON											-		-
OOI											-		-
RSVP											-		-
Scientific Ocean Drilling											-		-
South Pole Station Modernization											-		-
Terascale Computing Systems											-		-
MREFC Subtotals	**-**	**-**	**-**	**-**	**$136,180**	**-**	**-**	**-**	**$11,330**	**-**	**$147,510**	**-**	**$147,510**
Total FY 2009 Submission by Activity including MREFC	**$675,060**	**$638,760**	**$759,330**	**$848,670**	**$1,538,850**	**$233,480**	**$220,080**	**$47,440**	**$503,830**	**$276,000**	**$5,741,500**	**$790,410**	**$6,531,910**
STEWARDSHIP													
Direct AOAM													
Space Rental	3,400	1,991	3,370	2,972	3,830	3,186	276	1,103	1,287		$21,415	$3,585	$25,000
PC&B	26,061	15,260	25,826	22,774	29,347	24,417	2,113	8,452	9,861		$164,111	$27,469	$191,580
Distributed AOAM	1,928	1,129	1,910	1,684	2,171	1,806	156	625	729		$12,138	$2,032	$14,170
Direct AOAM Subtotals	**$31,389**	**$18,380**	**$31,106**	**$27,430**	**$35,348**	**$29,409**	**$2,545**	**$10,180**	**$11,877**		**$197,664**	**$33,086**	**$230,750**
Indirect AOAM Cost Allocation	10,108	5,919	10,018	8,833	11,383	9,471	820	3,278	3,825		$63,655	$10,655	$74,310
Direct & Indirect AOAM Subtotals	**$41,497**	**$24,299**	**$41,124**	**$36,263**	**$46,731**	**$38,880**	**$3,365**	**$13,458**	**$15,702**		**$261,319**	**$43,741**	**$305,060**
NSB Allocation	**$548**	**$321**	**$543**	**$479**	**$617**	**$514**	**$44**	**$178**	**$207**		**$3,451**	**$578**	**$4,030**
OIG Allocation	**$1,782**	**$1,044**	**$1,766**	**$1,557**	**$2,007**	**$1,670**	**$144**	**$578**	**$674**		**$11,222**	**$1,878**	**$13,100**
NSF TOTAL	**$718,887**	**$664,424**	**$802,763**	**$886,969**	**$1,588,205**	**$274,544**	**$223,633**	**$61,654**	**$520,413**	**$276,000**	**$6,017,492**	**$836,607**	**$6,854,100**

FY 2009 FULL BUDGETARY COSTING

Table 2: Allocation by Discovery, Learning, and Research Infrastructure
(Dollars in Thousands)

Total Directorate FY 2009	BIO	CISE	ENG	GEO	MPS	SBE	OCI	OISE	OPP	IA	R&RA	EHR	TOTAL
Discovery	528,971	596,693	709,367	491,891	1,026,929	215,343	28,298	43,565	127,141	143,965	3,912,163	190,955	**4,103,119**
Learning	46,509	39,730	58,609	32,542	70,974	11,324	4,219	18,089	5,805	13,605	301,406	628,470	**929,876**
Research Infrastructure	143,407	28,001	34,787	362,536	490,302	47,877	191,116		387,467	118,430	1,803,923	17,182	**1,821,105**
FULL BUDGETARY COST	**$718,887**	**$664,424**	**$802,763**	**$886,969**	**$1,588,205**	**$274,544**	**$223,633**	**$61,654**	**$520,413**	**$276,000**	**$6,017,492**	**$836,607**	**$6,854,100**

Totals may not add due to rounding.

NATIONAL SCIENCE FOUNDATION

Research and Development Special Analysis

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Support of R&D			
Conduct of Research and Development			
Basic Research	$3,618.37	$3,691.65	$4,320.06
Applied Research	351.74	339.80	421.94
Subtotal, Conduct of R&D	3,970.11	4,031.45	4,742.00
R&D Facilities			
Land, Building and Fixed Equipment	23.60	13.00	14.63
Major Equipment	413.15	464.64	418.31
Subtotal, R&D Facilities & Major Equipment	436.75	477.64	432.94
Total, Support of R&D	4,406.86	4,509.09	5,174.94
Non-Investment Activities	674.98	729.11	777.85
Education and Training	802.53	826.80	901.31
TOTAL	$5,884.37	$6,065.00	$6,854.10

Totals may not add due to rounding.

RESEARCH AND RELATED ACTIVITIES

Research and Development Special Analysis

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Support of R&D			
Conduct of Research and Development			
Basic Research	$3,567.19	$3,637.65	$4,260.06
Applied Research	346.91	334.80	415.94
Subtotal, Conduct of R&D	3,914.10	3,972.45	4,676.00
R&D Facilities			
Land, Building and Fixed Equipment	23.60	13.00	14.63
Major Equipment	246.94	243.90	270.80
Subtotal, R&D Facilities & Major Equipment	270.54	256.90	285.43
Total, Support of R&D	4,184.64	4,229.35	4,961.43
Non-Investment Activities	386.16	405.92	427.66
Education and Training	187.65	186.20	204.90
TOTAL	$4,758.45	$4,821.47	$5,593.99

Totals may not add due to rounding.

Includes funding for EPSCoR for all years shown for comparability. EPSCoR has been transferred from Education and Human Resources to R&RA.

EDUCATION AND HUMAN RESOURCES

Research and Development Special Analysis

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Support of R&D			
Conduct of Research and Development			
Basic Research	$51.18	$54.00	$60.00
Applied Research	4.83	5.00	6.00
Subtotal, Conduct of R&D	56.01	$59.00	$66.00
R&D Facilities			
Land, Building and Fixed Equipment	-	-	-
Major Equipment	-	-	-
Subtotal, R&D Facilities & Major Equipment	-	-	-
Total, Support of R&D	56.01	59.00	66.00
Non-Investment Activities	24.76	26.00	28.00
Education and Training	614.88	640.60	696.41
TOTAL	$695.65	$725.60	$790.41

Totals may not add due to rounding.

Excludes funding for EPSCoR for all years shown for comparability. EPSCoR has been transferred from Education and Human Resources to R&RA.

MAJOR RESEARCH EQUIPMENT FACILITIES CONSTRUCTION

Research and Development Special Analysis

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Support of R&D			
Conduct of Research and Development			
Basic Research	-	-	-
Applied Research	-	-	-
Subtotal, Conduct of R&D	-	-	-
R&D Facilities			
Land, Building and Fixed Equipment	-	-	-
Major Equipment	$166.21	$220.74	$147.51
Subtotal, R&D Facilities & Major Equipment	166.21	220.74	147.51
Total, Support of R&D	166.21	220.74	147.51
Non-Investment Activities	-	-	-
Education and Training	-	-	-
TOTAL	$166.21	$220.74	$147.51

Totals may not add due to rounding.

AGENCY OPERATIONS AND AWARD MANAGEMENT

Research and Development Special Analysis

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Support of R&D			
Conduct of Research and Development			
Basic Research	-	-	-
Applied Research	-	-	-
Subtotal, Conduct of R&D	-	-	-
R&D Facilities			
Land, Building and Fixed Equipment	-	-	-
Major Equipment	-	-	-
Subtotal, R&D Facilities & Major Equipment	-	-	-
Total, Support of R&D	-	-	-
Non-Investment Activities	$248.49	$281.79	$305.06
Education and Training	-	-	-
TOTAL	$248.49	$281.79	$305.06

Totals may not add due to rounding.

OFFICE OF INSPECTOR GENERAL

Research and Development Special Analysis

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Support of R&D			
Conduct of Research and Development			
Basic Research	-	-	-
Applied Research	-	-	-
Subtotal, Conduct of R&D	-	-	-
R&D Facilities			
Land, Building and Fixed Equipment	-	-	-
Major Equipment	-	-	-
Subtotal, R&D Facilities & Major Equipment	-	-	-
Total, Support of R&D	-	-	-
Non-Investment Activities	$11.92	$11.43	$13.10
Education and Training	-	-	-
TOTAL	$11.92	$11.43	$13.10

Totals may not add due to rounding.

NATIONAL SCIENCE BOARD

Research and Development Special Analysis

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Support of R&D			
Conduct of Research and Development			
Basic Research	-	-	-
Applied Research	-	-	-
Subtotal, Conduct of R&D	-	-	-
R&D Facilities			
Land, Building and Fixed Equipment	-	-	-
Major Equipment	-	-	-
Subtotal, R&D Facilities & Major Equipment	-	-	-
Total, Support of R&D	-	-	-
Non-Investment Activities	$3.65	$3.97	$4.03
Education and Training	-	-	-
TOTAL	$3.65	$3.97	$4.03

Totals may not add due to rounding.