NSF FY 2014 Budget Request to Congress

The National Science Foundation Act of 1950 (Public Law 81-507) sets forth our mission: ***To promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense.***

*The National Science Foundation Strategic Plan for FY 2011 – 2016, "Empowering the Nation Through Discovery and Innovation," defines our vision: "****a nation that capitalizes on new concepts in science and engineering and provides global leadership in advancing research and education.****"*

The National Science Foundation (NSF) is the only federal agency dedicated to the support of basic research and education across all fields of science and engineering. For over 60 years, NSF has had a profound impact on our Nation's innovation ecosystem by funding transformative research that has explored – and extended – the frontiers of scientific knowledge, promoted new industries, and addressed societal challenges.

In an era of fiscal austerity and focus on return on investment for the U.S. taxpayer, the strategic investments in NSF's FY 2014 portfolio sustain national economic growth, create new high technology jobs, support the transition to a clean energy economy, and train and develop the Nation's globally competitive science and engineering (S&E) workforce.

NSF's FY 2014 Budget Request is $7.626 billion, an increase of $592.69 million (8.4 percent) over the 2012 Enacted level. This request reflects a rigorous prioritization of activities across the Foundation. Even as the overall budget grows, the Agency Operations and Award Management account increases only $4.89 million (1.6 percent) as administrative costs are kept constrained. Approximately $37 million in lower priority education and research programs are terminated, reduced, or consolidated.

NSF Funding by Account
(Dollars in Millions)

	FY 2012 Enacted	FY 2014 Request	FY 2014 Request Change Over FY 2012 Enacted Amount	Percent
Research & Related Activities	$5,689.00	$6,212.29	$523.29	9.2%
Education & Human Resources	829.00	880.29	51.29	6.2%
Major Research Equipment & Facilities Construction	197.06	210.12	13.07	6.6%
Agency Operations & Award Management	299.40	304.29	4.89	1.6%
National Science Board	4.44	4.47	0.03	0.7%
Office of Inspector General	14.20	14.32	0.12	0.8%
Total, NSF	**$7,033.10**	**$7,625.78**	**$592.69**	**8.4%**

Totals may not add due to rounding.

FY 2014 Priorities

Funding for FY 2014 Priorities
(Dollars in Millions)

Investment Priority	FY 2012 Enacted	FY 2014 Request	FY 2014 Request Change Over FY 2012 Enacted Amount	Percent
Cyber-Enabled Materials, Manufacturing and Smart Systems (CEMMSS)	$141.65	$300.42	$158.77	112.1%
Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21)	78.00	155.47	77.47	99.3%
NSF Innovation Corps (I-Corps)	7.50	24.85	17.35	231.3%
Integrated NSF Support Promoting Interdisciplinary Research & Education (INSPIRE)	20.35	63.00	42.65	209.6%
Science, Engineering, and Education for Sustainability (SEES)	157.00	222.79	65.79	41.9%
Secure and Trustworthy Cyberspace (SaTC)	111.75	110.25	-1.50	-1.3%

Investments may have funding overlap and thus should not be summed.

The investments that form this Budget Request flow from the goals established in the agency's strategic plan: Transform the Frontiers, Innovate for Society, and Perform as a Model Organization. In FY 2014, key NSF investments in all fields of science and engineering strive to create new knowledge, stimulate discovery, address complex societal problems, and promote national prosperity.

In keeping with NSF's mission of advancing basic research in science, engineering, and education, this Request ensures the health of fundamental science and engineering across all disciplines, primarily through merit reviewed awards to researchers at colleges and universities throughout the country. There are six areas where core research is encouraged to enable scientists to address problems that require integration across more than one discipline. These priority investments, which encompass roughly 11 percent of the FY 2014 Request, focus on areas where progress in basic research is vital to addressing key national challenges, such as spurring innovation in manufacturing, improving data storage and analysis (e.g., Big Data), securing critical infrastructure, and promoting innovation and economic growth generally. Priorities include:

- **Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS**) ($300.42 million) will transform static systems, processes, and edifices into adaptive, pervasive "smart" systems with embedded computational intelligence that can sense, adapt, and react. Through CEMMSS, NSF participates in the Administration's Materials Genome Initiative (MGI), the National Robotics Initiative (NRI), and the Advanced Manufacturing Partnership. These investments fund research in areas of national importance, such as cyber-physical systems and advanced robotics research, materials processing and manufacturing, and advanced semiconductor and optical device design. These efforts are integral to the Administration's overall emphasis on strengthening advanced manufacturing.

- **Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21)** ($155.47 million) aims to expand investment in the Big Data/National Data Infrastructure program, a joint solicitation with the National Institutes of Health (NIH). NSF, as the lead agency, strives to coordinate development of new knowledge, tools, practices, and infrastructure that will enable breakthrough discoveries in science, engineering, medicine, commerce, education, and national security.

- **NSF Innovation Corps (I-Corps)** ($24.85 million) continues to build a national innovation ecosystem by improving NSF-funded researchers' access to resources that can assist in bridging the gap between discoveries and downstream technological applications, including commercialization of new technologies, products, and processes. In FY 2014, NSF will continue investment in Innovation Teams, and will expand support for I-Corps Nodes and I-Corps Sites.

- **Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE)** ($63.0 million) investment will continue to strengthen NSF's support of interdisciplinary, potentially transformative research by complementing existing efforts with a suite of highly innovative Foundation-wide activities and funding opportunities.

- **Science, Engineering, and Education for Sustainability (SEES)** ($222.79 million) addresses the need to develop a sustainable world where human needs are met equitably without harm to the environment and without sacrificing the ability of future generations to meet their needs. SEES uses a systems-based approach to understanding, predicting, and reacting to change in the linked natural, social, and built environment and addresses challenges in environmental and energy research and education. In FY 2014, NSF focuses on enhancing the Water Sustainability and Climate, Cyber-SEES, Hazards, and Sustainable Chemistry, Engineering and Materials (SusChEM) programs.

- The **Secure and Trustworthy Cyberspace (SaTC)** ($110.25 million) investment aligns NSF's cybersecurity investments with the four thrusts outlined in the national cybersecurity strategy, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program*. SaTC seeks to protect the Nation's information technology infrastructure from a wide range of threats that challenge its security, reliability, availability, and overall trustworthiness.

Additional Priorities and Highlights

- NSF aims to increase the operational efficiency of **U.S. activities in the Antarctic** ($22.0 million) by implementing the recommendations of the U.S. Antarctic Program Blue Ribbon Panel (BRP) report, *More and Better Science in Antarctica through Increased Logistical Effectiveness*. Emphases include safety and health improvements, investments with positive net present value, and facilities renewal at McMurdo and Palmer stations. Additionally, NSF aims to plan and execute more effective observational approaches to the Antarctic science community, as outlined in the 2011 National Research Council report, *Future Science Opportunities in Antarctica and the Southern Ocean*.

- In FY 2014, NSF introduces three activities to improve program effectiveness and efficiency by:

    - Ensuring **Public Access** ($2.50 million) to NSF research. This initiative reflects the Administration and NSF priority to make government more open and accessible by improving public access to NSF-funded research. In FY 2014, NSF establishes a policy framework that will build on and refine existing technology to track research products, allow investigators and awardees to make their products known and available, and allow the general public, researchers, and policy makers to locate and make use of those products. This effort includes establishing a

publicly-accessible repository for publications, leveraging existing federal infrastructure to the maximum extent possible.

- Establishing an **Evaluation Capability** ($5.50 million) to improve NSF's ability to inform policy decisions and improve the impact of research grant investments. In FY 2014, NSF will build a central evaluation expertise and support capability to promote rigor, transparency, and independence of evaluations. The centralized capability will coordinate the evaluation of NSF-wide activities, expand data collection, and ensure that the results of evaluation are used to improve NSF programs.

- Improving the operational execution of the **Merit Review Process** ($4.09 million), an essential step to address the extraordinary pressures the Foundation faces due to a growing number of proposals and intense competition for NSF funding. The FY 2014 Request will support a multi-year effort to improve major aspects of this process, including use of virtual meeting technologies for merit review; technological support for the management of reviewers and reviews; increased automation of the preliminary processing of proposals; and demand management.

- **Clean Energy** ($372.45 million): NSF's clean energy investments include research related to sustainability science and engineering, such as the conversion, storage, and distribution of diverse power sources (including smart grids), and the science and engineering of energy materials, energy use, and energy efficiency.

- **Research at the Interface of Biological, Mathematical and Physical Sciences, and Engineering (BioMaPS)** ($50.67 million) is a collaboration among the Directorates for Biological Sciences, Mathematical and Physical Sciences, and Engineering, that seeks to discover fundamental knowledge at the intersections of these established disciplines. This activity will produce critical knowledge needed to catalyze the development of new technologies essential to the Nation's prosperity and economic competitiveness and will advance emerging areas of the bioeconomy, as described in the Administration's *National Bioeconomy Blueprint*.

- The **Cognitive Science and Neuroscience** investment ($13.85 million) supports a focused, cross-foundation activity with three multi-year goals: to advance understanding of adaptation to the ever-changing world; to determine the mechanisms underlying decision-making and problem-solving in a dynamic environment; and to break the neural code by elucidating how the brain represents the world around us. This builds on ongoing NSF-wide support (approximately $70 million per year) for fundamental research relevant to cognitive science and neuroscience. NSF's funding in FY 2014 will also contribute to the Administration's multi-agency research initiative designed to revolutionize understanding of the human brain. FY 2014 activities include workshops held to identify specific gaps in our current understanding of these issues and intractable technology problems that prevent scientific breakthroughs. These will allow development of a framework for future efforts in the Administration's initiative.

- **The Faculty Early Career Development program (CAREER)** ($223.73 million) develops the future STEM workforce through support of young faculty who are dedicated to integrating research with teaching and learning. In FY 2014, NSF will support approximately 500 new awards. The CAREER portfolio includes projects that range across all fields of science and engineering supported by the Foundation, including high priority fields such as clean energy, climate change, STEM education, and cybersecurity. Within CAREER, NSF will support more fully utilizing the talents of individuals in all sectors of the American population by promoting Career-Life Balance, including

supplemental funding requests to employ research technicians or the equivalent for up to three months to sustain research when principal investigators are on family leave.

Science, Technology, Engineering, and Mathematics (STEM) Education

NSF maintains a strong commitment to advancing science and engineering education at all levels and to strengthening the Nation's workforce in STEM. The Administration is proposing a government-wide reorganization of STEM education programs to support a cohesive national STEM strategy. As part of this reorganization, in FY 2014 NSF presents a comprehensive agency-wide program to address undergraduate education and expands its leadership role in graduate education.

- The **National Graduate Research Fellowship program (NGRF)** ($325.14 million) builds on and expands the longstanding NSF Graduate Research Fellowship program (GRF) to incorporate features and opportunities that allow fellows to gain specialized experiences and training in key STEM areas. Through this expanded program, an increase of approximately 700 fellows is expected, bringing the total estimated number of new fellows awarded in FY 2014 to 2,700.

- The **NSF Research Traineeships (NRT)** program ($55.07 million) is the Foundation's investment in traineeships that focus on strategically identified research areas, mutually leveraging NSF's traineeship and research investments. NRT will build on NSF's previous investments – particularly the Integrative Graduate Education and Research Traineeship (IGERT) program – to encourage effectual innovation and design of graduate programs to support opportunities within specific disciplines.

- **Catalyzing Advances in Undergraduate STEM Education (CAUSE)** ($123.08 million) is a comprehensive agency-wide program for FY 2014 that aims to maximize the impact of NSF's considerable ongoing investments in STEM undergraduate education. CAUSE aims to improve STEM learning and learning environments; broaden participation in STEM and increase institutional capacity; and build the STEM workforce of tomorrow.

- Funding for the **Research Experiences for Undergraduates (REU) Sites and Supplements** ($79.18 million total) is increased $13.19 million over the FY 2012 Enacted. This additional funding will support enhanced research experiences for students in their first two years of college, as recommended by the President's Council of Advisors on Science and Technology (PCAST) in their report, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*.

Major Research Equipment and Facilities Construction

In FY 2014, NSF requests funding to continue construction of four projects: the Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO), the Advanced Technology Solar Telescope (ATST), the National Ecological Observatory Network (NEON), and the Ocean Observatories Initiative (OOI).

Funds are also requested to begin construction of the Large Synoptic Survey Telescope (LSST), a partnership with the Department of Energy (DOE). LSST was ranked as the number one priority for a large ground-based astronomical facility in the National Academies' most recent *Decadal Survey of Astronomy and Astrophysics* (August 2010).

- **Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO).** A planned upgrade of the existing Laser Interferometer Gravitational-Wave Observatory (LIGO), AdvLIGO will be ten times more sensitive, powerful enough to approach the ground-based limit of gravitational-wave detection.
- **Advanced Technology Solar Telescope (ATST).** ATST will enable study of the sun's magnetic fields, which is crucial to our understanding of the types of solar variability and activity that affect Earth's civil life and may impact its climate.
- **Large Synoptic Survey Telescope (LSST).** LSST will produce an unprecedented wide-field astronomical survey of our universe, including the deepest, widest-field sky image ever. The LSST survey will change every field of astronomical study, from the inner solar system to the large scale structure of the universe.
- **National Ecological Observatory Network (NEON).** NEON will consist of geographically distributed field and lab infrastructure networked via cybertechnology into an integrated research platform for regional to continental scale ecological research.
- **Ocean Observatories Initiatives (OOI).** OOI will enable continuous, interactive access to the ocean via multiple types of sensors linked by cutting-edge cyberinfrastructure, which will produce never-before-seen views of the ocean's depths.

MREFC Account Funding, by Project
(Dollars in Millions)

	FY 2012 Enacted	FY 2014 Request
Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO)	$20.96	$14.92
Atacama Large Millimeter Array (ALMA)	3.00	-
Advanced Technology Solar Telescope (ATST)	10.00	42.00
Large Synoptic Survey Telescope (LSST)	-	27.50
National Ecological Observatory Network (NEON)	60.30	98.20
Ocean Observatories Initiative (OOI)	102.80	27.50
Total, MREFC	**$197.06**	**$210.12**

Totals may not add due to rounding.

Model Organization

To "Perform as a Model Organization" is an internally focused strategic goal that emphasizes the agency's desired outcome of attaining excellence in all aspects of its operations. Model Organization underpins NSF programmatic activities and encompasses all the agency's management activities. It also includes support for the activities of the Office of Inspector General (OIG) and the National Science Board (NSB), which are provided in separate appropriations.

iTRAK

NSF will continue to modernize its financial management systems through the implementation of iTRAK. iTRAK will transition NSF from its legacy financial system to a fully integrated financial management solution. In FY 2014, the total request for iTRAK is $2.60 million.

Promoting Efficient Spending

Efforts are underway in multiple accounts to reduce administrative costs through efficiencies in response to the Administration's Promoting Efficient Spending initiative (Executive Order 13589) and *Promoting Efficient Spending to Support Agency Operations* (OMB M-12-12). Travel costs across NSF will be held at no more than $27.67 million in FY 2014, an amount $5.60 million below FY 2010 levels. This is accomplished through strategic efficiencies that achieve savings while preserving the travel necessary for mission-critical oversight and management responsibilities. In addition, NSF will also employ strategic sourcing of administrative support contracts, specifically for printing and wireless devices.

Model Organization by Appropriations Account

(Dollars in Millions)

	FY 2012 Enacted	FY 2014 Request	FY 2014 Request Change Over FY 2012 Enacted Amount	Percent
Agency Operations and Award Management	$299.40	$304.29	$4.89	1.6%
Office of Inspector General	14.20	14.32	0.12	0.8%
National Science Board	4.44	4.47	0.03	0.7%
Program Support:				
Research & Related Activities	94.12	108.20	14.08	15.0%
Education and Human Resources	15.39	16.57	1.18	7.7%
Subtotal, Program Support	109.51	124.77	15.26	13.9%
Total	**$427.55**	**$447.85**	**$20.30**	**4.7%**

Performance and Evaluation

NSF embraces the use of goals to drive performance improvements. In FY 2014, NSF has set ten performance goals so that NSF can strategically monitor and oversee progress being made on the Foundation's most important activities: priority program investments, research infrastructure investments and key management initiatives. NSF's goals are:

- **Ensure that Key Program Investments are on track:** Meet critical targets for several key program investments: CEMMSS, CIF21, I-Corps, INSPIRE, SaTC, and SEES. Progress will be monitored using a set of common milestones and indicators.

- **Ensure that Infrastructure Investments are on track:** Ensure program integrity and responsible stewardship of major research facilities at varying stages of their lifecycle. This involves construction project monitoring, response to advisory reports, and deployment of the first implementation of the NSF Public Access system.

- **Use Evidence to Guide Management Decisions:** The Foundation will use evidence-based reviews to guide management investments.

- **Improve Undergraduate Education:** The Foundation will establish an NSF-wide undergraduate STEM education program that is evidence-based and evidence-building.

- **Enhance National Graduate Research Fellowships:** NSF will enhance the Graduate Research Fellowship program to provide a wider range of career development opportunities.

- **Promote Career-Life Balance Policies and Practices:** NSF aims to promote policies and practices that support more fully utilizing the talents of individuals in all sectors of the American population, principally women, underrepresented minorities, and persons with disabilities.

- **Foster an Environment of Diversity and Inclusion:** The Foundation seeks to foster an environment of diversity and inclusion while ensuring compliance with the agency's civil rights programs.

- **Modernize Financial System:** iTRAK is the Foundation-wide effort to transition NSF from its legacy financial support system to a fully integrated financial management shared services solution to ensure continuous improvement and achieve high levels of customer service.

- **Make Timely Award Decisions:** NSF aims to inform applicants whether their proposals have been declined or recommended for funding within 182 days, or six months of deadline, target, or receipt date, whichever is later.

- **Enable Increased Use of Virtual Merit Review:** NSF seeks to incorporate technological innovations into the merit review process by expanding the use of virtual merit review panels.

Please refer to performance.gov for information on NSF's agency Priority Goals and NSF's contributions to the federal Cross-Agency Priority (CAP) goals.

Cuts, Consolidations, and Savings

NSF's FY 2014 Request follows a thorough examination of programs and investments across NSF to determine where the potential exists for more innovative investments. In addition to last year's proposals, this Request includes six terminations; two reductions; and one consolidations, totaling $36.86 million below FY 2012 Enacted level.

Nanoscale Science & Engineering Centers (NSECs) (-$18.61 million)**:** six NSEC centers are terminated due to center graduations and a transition to the Nanosystems Engineering Research Centers (NERCs) program. NSF will continue to support five continuing NSECs in FY 2014.

Two programs are eliminated within the Directorate for Mathematical and Physical Sciences (MPS). **CCAT** (formerly the Cerro Chajnantor Atacama Telescope) **Design and Development** (-$1.50 million total) concludes in FY 2013. Future NSF contributions to construction and/or operations will depend on a successful proposal to a competed midscale activities program. The **International Materials Institutes (IMI)** (-$1.58 million total) were concluded after an internal evaluation of program achievements found that despite the success of individual projects, the collective effort has not made the intended impact.

Virtual Organizations (-$5.0 million total) has achieved its programmatic goals to support scientific research to advance understanding of the effectiveness of virtual organizations and how they can enable and enhance science and engineering research and education. The transition to supporting application of virtual organizations to science and engineering communities is now underway in multiple programs within the Directorate for Computer and Information Science and Engineering.

The **Sensors and Sensing Systems (SSS)** program (-$3.0 million) is reduced because there are other programs both within NSF and at other agencies that principal investigators can apply to for support. The program will be refined to have a narrower and more targeted focus.

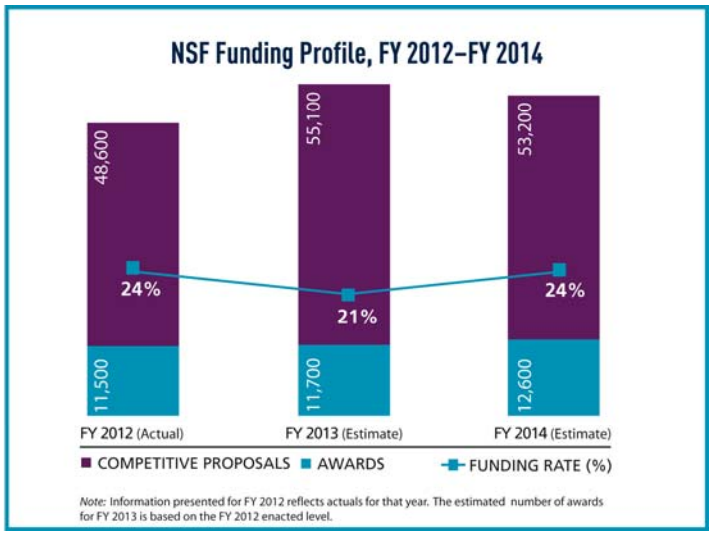
University Radio Observatories (UROs) (-$1.80 million) is being superseded scientifically by NSF's Atacama Large Millimeter/submillimeter Array (ALMA). It is expected that UROs will be eligible to compete for future funding in a broader midscale activities program.

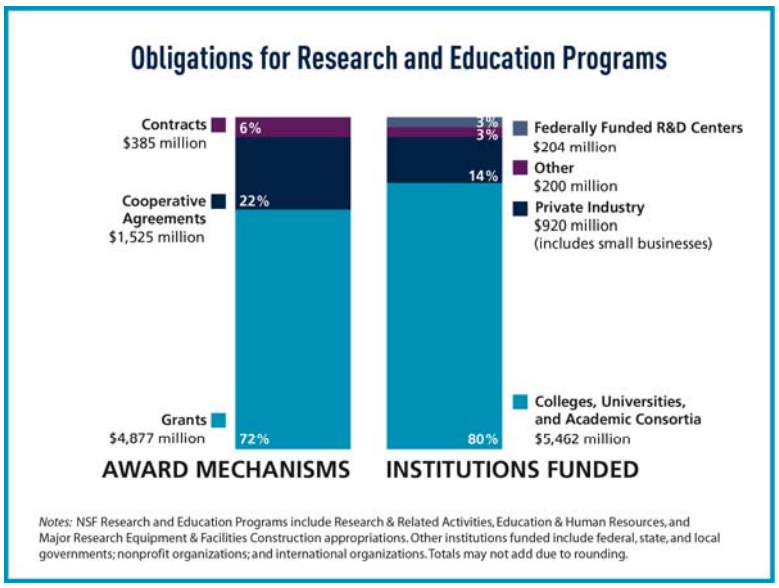
The Directorate for Education and Human Resources (EHR) will shepherd two major realignments to the current NSF STEM Education portfolio in order to use existing resources more effectively through a streamlined and consolidated approach. The new **Catalyzing Advances in Undergraduate STEM Education (CAUSE)** program includes undergraduate programs in EHR as well as Research and Related Activities (R&RA) directorates. NSF will take a leadership role in the coordination of government-wide graduate STEM education programs while developing national fellowship and traineeship programs.

As part of NSF's realignment of its STEM Education portfolio, two programs are terminated within the Directorate for Geosciences (GEO). The goals of the **Geoscience Teacher Training (GEO-Teach)** (-$2.0 million) program continue to be served through other STEM education initiatives at NSF. The **Centers for Ocean Science Education Excellence (COSEE)** (-$3.37 million) is terminated as the program has fulfilled its original goals. GEO will turn its attention to new educational initiatives through CAUSE.

NSF by the Numbers

NSF by The Numbers: In FY 2014 NSF expects to evaluate over 53,000 proposals through a competitive merit review process and make over 12,000 new awards. This will require over 260,000 proposal reviews, engaging on the order of 40,000 to 50,000 members of the science and engineering community participating as panelists and proposal reviewers. In a given year, NSF awards reach nearly 1,900 colleges, universities, and other public and private institutions in 50 states, the District of Columbia, and Puerto Rico. In FY 2014, NSF support is expected to reach approximately 276,000 researchers, postdoctoral fellows, trainees, teachers, and students.





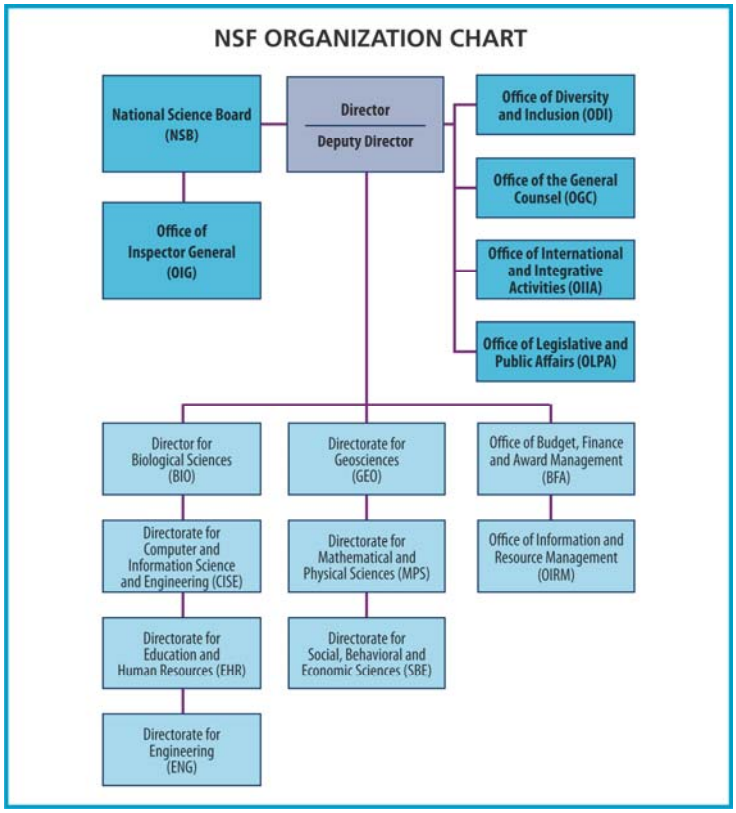
The chart on the left shows the distribution of NSF's obligations by institution type and funding mechanism. While the data are based on FY 2012, the relative shares should provide a good indication of the FY 2014 distribution. As shown on the graph, 94 percent of NSF's FY 2012 projects were funded using grants or cooperative agreements. Grants can be funded either as standard awards, in which funding for the full duration of the project is provided in a single fiscal year, or as continuing awards, in which funding for a multi-year project is provided in increments. Cooperative agreements are used when the project requires substantial agency involvement during the project performance period (e.g., research centers, multi-user facilities, etc.). Contracts are used to acquire products, services, and studies (e.g., program evaluations) required primarily for NSF or other government use.

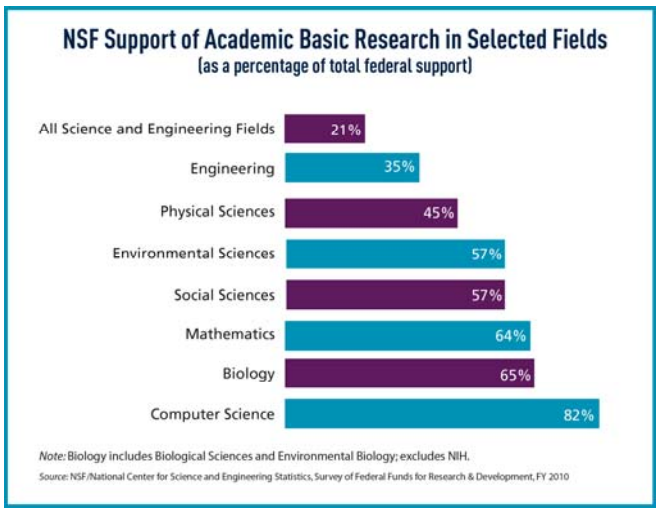
Most NSF awards are to academic institutions. Nonprofit organizations include state and local governments and international organizations. For-profit businesses include private and small businesses. Federal agencies and laboratories include funding for Federally Funded Research & Development Centers.

Organization and Role in the Federal Research Enterprise

NSF's comprehensive and flexible support of meritorious projects with broad societal impacts enables the Foundation to identify and foster both fundamental and transformative discoveries within and among fields of inquiry. NSF has the latitude to support emerging fields, high-risk ideas, interdisciplinary collaborations, and research that pushes – and even transforms – the very frontiers of knowledge. In these ways, NSF's discoveries inspire the American public – and the world.

NSF's organization represents the major science and engineering fields, including: biological sciences; computer and information science and engineering; engineering; geosciences; mathematical and physical sciences; and social, behavioral, and economic sciences. NSF also carries out specific responsibilities for education and human resources, cyberinfrastructure, integrative activities, international science and engineering, and polar programs. The 25-member National Science Board sets the overall policies of the Foundation.





NSF's annual budget represents 21 percent of the total federal budget for basic research conducted at U.S. colleges and universities, and this share increases to 58 percent when medical research supported by the National Institutes of Health is excluded. In many fields NSF is the primary source of federal academic support.

Highlights

Artificial Leaf Offers New Approach to Energy Production

Researchers at the Powering the Planet Center for Chemical Innovation at Caltech have created an artificial leaf. Just as a natural leaf converts sunlight into water, oxygen and sugar, this stand-alone device captures solar energy and splits water into hydrogen and oxygen gas. The artificial leaf converts sunlight into chemical fuel using a silicon photovoltaic cell and relatively inexpensive catalysts – materials that jump-start chemical reactions. To compete with cheap fossil fuels, novel materials are needed to generate fuels from solar energy. The materials must be inexpensive and abundant and their production simple and low-cost. Through a sustainable distribution infrastructure, the artificial leaf could become a viable energy source for both developed and developing countries. This finding was cited by Time magazine as an innovation of the year for 2011.

Credit: Dan Nocera, Massachusetts Institute of Technology

Detecting Explosives With Carbon-based Materials

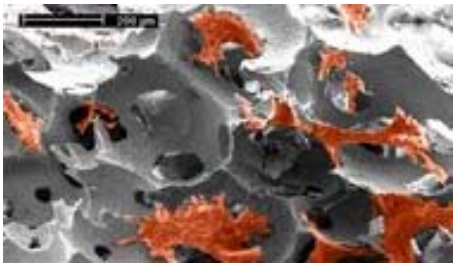
Researchers have created a novel carbon-based framework that produces materials for detecting explosive devices. Jeffrey Moore and his team at the University of Illinois, Urbana-Champaign, developed new methods to produce functionally useful materials based on carbon-rich nanostructures while reducing the generation of wasteful byproducts. The new methods allow for efficient, large-scale production and higher yields than previous methods.

Credit: Dorothy Loudermilk and Jeffrey Moore

This new environmentally friendly approach to explosive sensing materials has major implications for homeland security as well as combat soldiers who are targets of improvised explosive devices. These new materials are now being incorporated into field portable explosives detection devices.

Building Better Bone With Ceramics

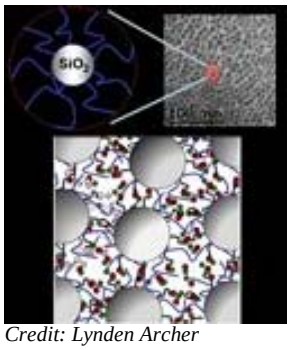
Researchers at the University of Florida have developed new ceramic foams that act as scaffolds for bone repair. These foams could mean an end to the use of metal plates as bone substitutes. Bioceramic foams are lightweight, porous, and possess a large surface area; porosity allows biofluids and arteries to flow through a ceramic implant, while high surface area allows more bone regeneration to occur. In experiments, the researchers demonstrated how cells spread across the foam struts, attach to inner foam pores and spread along foam contours. All of these steps are essential for bone regeneration and fracture healing.



Credit: Juan C. Nino, University of Florida

Highlights

Longer Life Lithium Batteries



Credit: Lynden Archer
Cornell University

Researchers from Cornell University have created a hybrid material that is particularly suitable for use as a solid electrical conductor or electrolyte in high-energy lithium batteries. Lynden Archer and his colleagues designed and refined new materials, composed of hard silica nanoparticles and a soft lithium-conducting polymer. The materials are stable, and have low flammability and volatility under battery operating conditions. Rechargeable lithium batteries are commonly used in consumer electronics and increasingly are finding applications in electric vehicles and defense. The new material will prolong the life of these batteries and allow them to provide higher powers than current technologies. A new start-up company – NOHMs Technologies – in Ithaca, N.Y., will manufacture and commercialize lithium batteries based on the new material.

Diagnosing Hidden Brain Trauma on the Field

The frontal cortex – the brain area directly behind the forehead – is vulnerable to damage. Scientists at the University of Texas Health Science Center in Houston, led by Anne Sereno and Saumil Patel, have discovered that people with impairments of the frontal cortex produce slower and more error-prone voluntary eye movements, but their reflexive eye and finger movements are unaffected. To evaluate whether even very mild injury to the frontal cortex has similar effects, the scientists developed a simple, tablet-based tool. The research team included a high-school student in the tool's development and tested the device with a local high-school women's soccer team. Results showed that frequent heading of balls – striking the ball with the forehead – disrupted and slowed voluntary movements in players tested right after soccer practice. These findings suggest that even mild injury to the frontal cortex can produce immediate, though short-lived, cognitive and behavioral changes that can affect one's ability to attend and respond to information or learn new information. This simple, tablet-based tool may be extremely useful for diagnosing deficits and evaluating treatment in mild traumatic brain injury at the time of injury, as well as for later follow-up care.

Credit: Anne Sereno,
University of Texas
Health Science Center

Imaging Groundwater Aquifers

Credit: Rosemary Knight, Stanford University

Most of the Earth's liquid fresh water exists as groundwater, a resource that lies beneath the Earth's surface. Conventional approaches to discover groundwater involve drilling and pumping wells, which are expensive and time-consuming. A Grant Opportunities for Academic Liaison with Industry (GOALI) project, involving researchers at Stanford University, the U.S. Geological Survey (USGS), and several industrial partners, used an alternative approach – surface nuclear magnetic resonance – which permits remote sampling and imaging of groundwater in less time, reducing monitoring costs. The approach also has applications in understanding the relationship between plant transpiration and groundwater.

Highlights

Understanding Urban Flooding

Credit: Parks & People Foundation

Although researchers agree that urban development affects flooding, in the past they have disagreed on how factors such as increases in impervious areas change the density of streams in the area. They have also debated whether the addition of storm drains affects flooding. A team of investigators from the University of Wyoming and University of Connecticut have gained new insights into how human and geological factors influence urban-area flooding. Using simulations, they discovered that the inability of surfaces to absorb water has a greater effect during heavy rainfall than during truly extreme events. In addition, small changes in drainage density--that is, the total length of streams and rivers in an area--significantly affect flood peaks in areas of already low drainage density. Subsurface storm drains can increase drainage density in areas lacking streams and rivers by providing more places for water to drain. However, the researchers found that depending on the existing stream network, watershed topography, and intensity and magnitude of a storm event, the addition of storm drains may have only a limited effect on the peak discharge.

PhysTEC Addresses Shortage of Physics Teachers

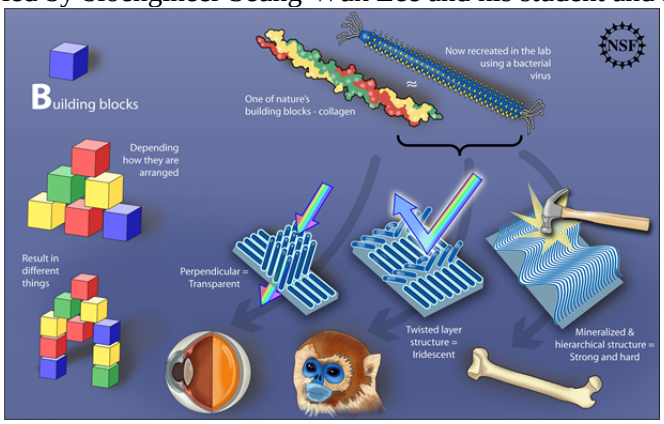
Credit: The Physics Teacher Education Coalition

School districts report a greater shortage of teachers in physics than in any other academic discipline. Only 35 percent of high-school physics teachers have a degree in physics or physics education. More than 250 colleges and universities have joined the Physics Teacher Education Coalition (PhysTEC), committing to educate greater numbers of highly qualified physics teachers. The PhysTEC project seeks to engage physics departments more deeply in teacher education so that every student will have the opportunity to learn physics from a qualified teacher. The PhysTEC members represent nearly one-third of all institutions offering physics degrees. Together these institutions graduate about 300 high-school physics teachers per year, addressing a significant fraction of the growing national need for 1400 new physics teachers per year. PhysTEC also organizes conferences and workshops, publishes articles and reports, and hosts listservs and websites (phystec.org and ptec.org) to more broadly connect with the physics community.

Highlights

Manufacturing Goes Viral

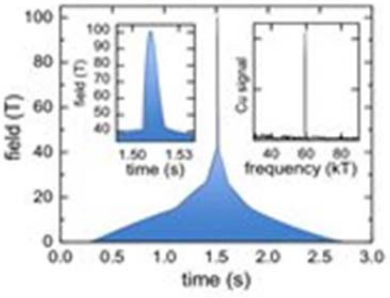
Using a simple, single-step process, engineers and scientists at the University of California at Berkeley, led by bioengineer Seung-Wuk Lee and his student and lead author Woo-Jae Chung, recently developed a technique to direct benign, filamentous viruses called M13 phages to serve as structural building blocks for materials with a wide range of properties. By controlling the physical environment alone, the researchers caused the viruses to self-assemble into hierarchically organized thin-film structures, with complexity that ranged from simple ridges, to wavy, chiral strands, to truly sophisticated patterns of overlapping strings of material. These results may also shed light on the self-assembly of biological tissues in nature. This novel, self-templating, biomaterials assembly process could be used in many other organic and inorganic materials to build hierarchical structures to tune optical, mechanical and even electrical properties from nano to macro scales. The reported approaches could be used to investigate mechanisms for diseases such as Alzheimer's, which is caused by amyloid aggregation in our brain tissues. More broadly, the breakthroughs could potentially yield scientific impacts in the area of tissue regeneration and repair.



Credit: Zina Deretsky, National Science Foundation

Super Magnet Breaks the Megagauss Barrier

Scientists and engineers at the National High Magnetic Field Laboratory (NHMFL) have successfully produced the highest nondestructive magnetic field ever – a field surpassing 100 tesla or 2 million times the Earth's magnetic field. Researchers will use this unprecedented tool to study a range of scientific activities--from unusual magnetic behaviors in materials to the quantum behavior of phase transitions in solids. The new magnet system--located at Los Alamos National Laboratory – achieved 100.75 tesla on March 22, 2012. The system is designed to pulse nondestructively in the intense 100-tesla realm on a regular basis. Magnets capable of higher field strengths have been created, but they explode after use because they cannot withstand the intense strength of the force created. The new magnet will also help researchers discover why superconductivity occurs in a newly discovered family of iron-based materials. This group of superconductors yields only to the highest magnetic fields. Superconducting magnets are used in everything from particle accelerators to magnetic resonance imaging machines. Nondestructive generation of 100 tesla magnetic fields has been a National Academy of Sciences Grand Challenge and a 15-year goal of the NHMFL. The project was jointly funded by the National Science Foundation and the Department of Energy.



Credit: Greg Boebinger, NHMFL, FSU

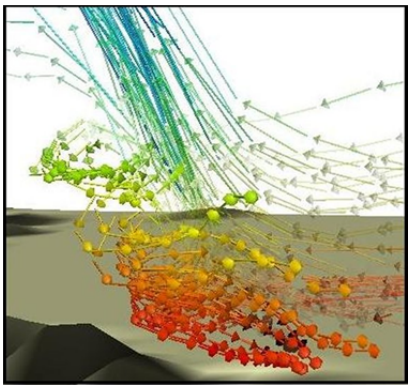
Highlights

State-of-the-Art Virtual Reality System is Key to Medical Discovery

Credit: Electronic Visualization Laboratory
University of Illinois at Chicago

A team of neurosurgeons from the College of Medicine at the University of Illinois at Chicago (UIC) recently stepped into CAVE2 – a next-generation, large-scale, virtual environment – to solve a vexing problem that presented itself in the arteries of the brain of a real patient. For years, the team had painstakingly used laptop and desktop computers to create three-dimensional, full-brain models that physiologically mirrored the brains of individual patients. These models were used for a patient whose cerebrovascular system they were trying to accurately model. But because of the limited image spatial-resolution of even today's best-quality computers, there was something the neurosurgeons couldn't see. That is, until they stepped into an automatic virtual environment, also known as a "CAVE" – a room in which images are seamlessly displayed so as to immerse an observer in a cyber-world of 3-D data. CAVE2 helped the team discover quickly that their model was “inconsistent with anatomy” – and with that revelation, their model could be corrected. The use of UIC's virtual reality system to make the discovery could help change the way surgeons are trained and greatly improve patient care – and the method could someday benefit hundreds of thousands of Americans who fall victim to brain aneurysms and strokes, the third leading cause of death in the United States. CAVE2 is funded through NSF's Major Research Instrumentation program and the Department of Energy.

Improving Tropical Cyclone Forecasts



Credit: Wallace Hogsett and Da-Lin Zhang
University of Maryland

Accurate tropical cyclone forecasts require prediction of tropical weather over vast tropical oceans; however, predicting cyclone formation is difficult due to the lack of direct observations in the formation regions and deficiencies in current models. The Weather Research and Forecasting (WRF) numerical model has captured the formation of a tropical cyclone within an area of disturbed weather associated with the Madden-Julian Oscillation (MJO) – a variable pattern of wind, rain, ocean temperature and cloudiness in the tropics. Results from the WRF research may lead the way to better modeling of tropical disturbances and improved forecasts to alert those in the tropics of potential cyclones. University of Maryland researchers have demonstrated that high-resolution models can describe slowly-evolving tropical weather patterns such as the MJO. Moreover, their results suggest that transient and small-scale weather phenomena such as tropical cyclones which develop within the disturbed weather associated with the MJO may be predictable.