Empowering the Nation Through Discovery and Innovation

NSF Strategic Plan for Fiscal Years (FY) 2011-2016

National Science Foundation

The Government Performance and Results Act (GPRA) (Public Law 103-62) requires Federal agencies to develop strategic plans setting forth missions, long-term goals, and means to achieving those goals, and ensure the effectiveness of agency programs through the integration of planning, budgeting, and performance measurement. "Empowering the Nation Through Discovery and Innovation: NSF Strategic Plan for Fiscal Years (FY) 2011-2016" updates and replaces "Investing in America's Future: NSF Strategic Plan FY 2006-2011." To develop this new plan, NSF formed a working group consisting of office and directorate deputies and others. This working group received input from NSF staff and from NSF's many advisory committee members representing the science and engineering community. The plan will be updated in FY2013 in accordance with the new requirements of the GPRA Modernization Act of 2010 (Public Law 111-352). To read more about strategic planning and performance measurement at NSF, please see www.nsf.gov/about/performance/ on our website.

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About the cover: Crystal growth traditionally has been viewed as the addition of small units to a monolith. But chemists from New York University (NYU) and Russia's St. Petersburg State University have discovered crystals that twist and untwist as they grow. The work could lead to a better understanding of the properties of high-polymers, which are used in clothing, liquid crystal displays and other consumer products. The researchers focused on growing crystals from undercooled melts of hippuric acid—a derivative of the amino acid glycine. As molecules are added to the end of fine crystalline needles, stresses build up at the tips of the crystals and result in a helical twist. When the crystals thicken from the opposite end of the growing tip, the process is reversed—the twisting is undone by stresses that build-up. The interplay of twisting and untwisting ultimately fixes the crystalline morphology. "This dynamic has not been observed before and points to a much more active process of crystal growth than we had anticipated," said Bart Kahr, NYU chemistry professor and one of the coauthors of a paper on the research. Kahr's work is supported by NSF grant number CHE-0845526. Credit: John Freudenthal and Alexander Shtukenberg, New York University

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April 2011

National Science Foundation

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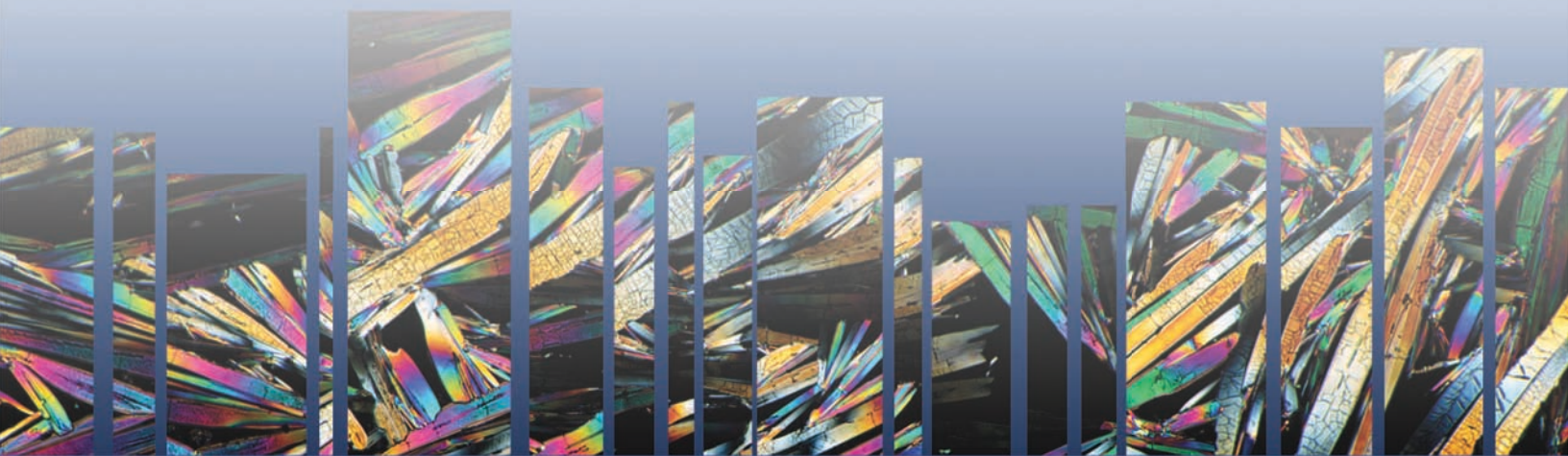


I. INTRODUCTION

The National Science Foundation (NSF) is the primary Federal agency supporting research at the frontiers of knowledge, across all fields of science and engineering (S&E) and all levels of S&E education. NSF-funded research and education projects —selected through competitive, merit-based review—have fueled many important innovations that in turn have stimulated economic growth and improved the quality of life and health for all Americans.

Investing in S&E is widely recognized as an essential pathway to the nation's future prosperity. Discoveries from S&E research form the cornerstone of the Administration's strategy for spurring innovation. The Administration's Educate to Innovate campaign, aimed at improving the participation and performance of America's students in science, technology, engineering, and mathematics (STEM), is also central.

NSF supports the basic research that underpins much of this national investment in research and development (R&D). Our support of research and education serves as the basis for actively shaping an increasingly dynamic and vigorous U.S. S&E enterprise. In fact, NSF's role in the U.S. S&E enterprise is so central that we are viewed by many as the "innovation agency."

"Empowering the Nation Through Discovery and Innovation: The National Science Foundation Strategic Plan for Fiscal Years (FY) 2011-2016" sets the Foundation's direction for the next five years. This document builds on previous plans. We have refined and refocused our vision statement and strategic goals to better integrate them with the concepts of research and learning, and more closely align with NSF's merit review criteria of *intellectual merit* and *broader impacts*.[1] We also draw upon new approaches and methods for assessing and evaluating the performance of NSF's investments in S&E research and education. Through this plan, NSF will extend and improve upon our tradition of accomplishment by taking stock of the past and looking to the future and the many opportunities that lie ahead.

NSF CORE VALUES

The NSF core values are essential and enduring tenets that influence everyone in the organization and support our mission. NSF is:

Cyber-physical Rehabilitation

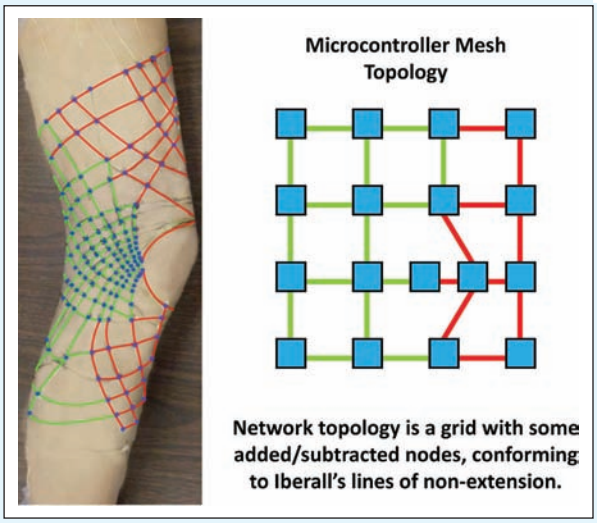


Image credit: Eugene Goldfield

NSF-supported research crosses disciplinary boundaries, applying new technologies, analytical techniques and cyber capabilities to long-standing questions. Psychologist Eugene Goldfield of the Center for Behavioral Science at Children's Hospital Boston, together with a team of engineers and scientists at the Wyss Institute, is in the early stages of a project that could help infants with early brain injury learn to move similar to other infants. Goldfield calls it "second skin"—smart clothing whose fabric would pick up attempts at motion and improve brain function. Tiny sensors and programmable muscle-like actuators within the material are designed to detect the motions of the limbs and add small forces that expand the range of motion and the wearer's ability to produce the motions. Data from studying babies' motion will be programmed into the second skin, with the aid of computer simulation, so that the actuators can provide the right kind of assistance. The expanded range of motion may provide new sensory information to promote restoration of brain function. The work is being conducted with infants because "the infant brain, when injured, has a remarkable capability for restoration of function," Goldfield said. If it proves successful, the technology could also be applied to others with mobility impairments, including children and adults with brain injuries, the aging population, and soldiers who are injured in combat. Read more about it.

1 To learn about NSF's merit review criteria, please see the section of the "Grant Proposal Guide" on proposal processing and review on our website at www.nsf.gov/pubs/policydocs/pappguide/nsf11001/gpg_3.jsp

Visionary—imagining the future, working at the frontier, realizing the full potential of the research and education community, embracing risk, advancing promising ideas wherever and whenever they arise, and encouraging creativity and initiative;

Dedicated to Excellence—investing optimally the resources entrusted to us, realizing the full potential of our people and managing a capable and motivated organization that provides an inclusive and positive work environment, and rewarding accomplishment;

Learning and Growing—continually improving our ability to identify opportunities, promoting learning and growth for the S&E community and the agency, and sharing our best insights with others;

Broadly Inclusive—seeking and including contributions from all sources while reaching out, especially to groups that are underrepresented, serving scientists, engineers, educators, students, and the public across the nation, and exploring opportunities for partnerships, both nationally and internationally; and

Accountable—operating with integrity and transparency, and maintaining quality in administration, management, and oversight.

II. MISSION

This plan follows the 60th anniversary of the establishment of NSF by the NSF Act of 1950 (Public Law 81-507). The NSF Act set forth a mission: *"to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes."*

The first part of this mission statement—*to promote the progress of science*—describes NSF's overall role in advancing research and education in S&E across all fields and disciplines and at all educational levels. We accomplish this mission by shaping and managing portfolios of the highest quality research and education projects, as determined by competitive merit review and national priorities. In so doing, NSF serves as the Federal government's principal steward of research and education across the

Researchers Respond to Disaster in the Gulf

Image credit: Luke McKay, University of Georgia

Disasters, both natural and human-caused, provide scientists and engineers with unique opportunities to gain new knowledge and apply new technologies and techniques in data collection, recovery, rebuilding and problem-solving. NSF's Grants for Rapid Research (RAPID) mechanism provides support to proposals for events that demand quick response. Within weeks of the April 2010 Deepwater Horizon oil rig explosion that killed 11 people and sent oil and gas spilling into the Gulf of Mexico, scientists supported by RAPID grants were quickly on the scene of the unfolding environmental catastrophe, collecting data, tracking the oil and gas plumes, and conducting analyses to provide an understanding of the impact on fragile ecosystems. For example, marine scientist Samantha Joye of the University of Georgia and her team traveled aboard the research vessel *F.G. Walton Smith* to study the effect of the released oil and gas on the diverse microbial community that had thrived in the sediments and deepwater of the Gulf. Joye later testified before Congress about her initial findings. Scientist David Valentine of the University of California at Santa Barbara and colleagues examined the impact of the dispersants used to degrade the spilled oil. "We're researching this real-world spill," Valentine said, "by simultaneously investigating oil composition, the microbes, and the dispersants. We think the dispersants may impact the microbes through interference with the action of their natural dispersants." Thomas Bianchi of Texas A&M, Robert Cook of Louisiana State University, and Mike Perdue of the Georgia Institute of Technology conducted a sampling trip in September 2010 and reported the Louisiana marshes contain twice as much dissolved organic carbon (DOC) compared to when they were sampled in July, shortly after the spill. The results add more details on the chemistry of the water changes after river diversions in response to the spill. By year's end, NSF had awarded more than 160 RAPID grants totaling more than $19 million to researchers for the scientific study of the spill's impact on the Gulf. Read more about it.

broadest range of scientific and engineering endeavors. NSF's workforce, in partnership with the S&E community at home and abroad, shapes our programs to provide the necessary research infrastructure and educational opportunities to ensure our nation has the world's most innovative and productive S&E enterprise.

The next part of the mission statement—*to advance the national health, prosperity, and welfare; to secure the national defense*—underscores NSF's contributions to addressing the nation's most pressing challenges. NSF supports the basic research and education that enable advances in many areas including technology-based innovations that spur economic prosperity; understanding, mitigating, and adapting to climate change; developing sustainable approaches to the utilization of energy, water, and other natural resources; and transforming undergraduate education for the preparation of tomorrow's leading scientists. NSF integrates research and education to support the development of a world-class scientific and engineering workforce as well as nurture the growth of a scientifically and technologically aware public, one that is able to engage fully in a 21st century life that increasingly relies on technology to meet challenges and grasp opportunities.

III. VISION

This plan establishes a vision that both underscores the agency's longstanding mission and highlights key opportunities and responsibilities for NSF in the 2011-2016 timeframe. The vision paints an inclusive picture for the future of science, engineering, and education in a diverse nation and challenges NSF to set our sights high—to pursue aggressively the strategic goals described in this plan to help achieve this vision.

> ***Vision: NSF envisions a nation that capitalizes on new concepts in science and engineering and provides global leadership in advancing research and education.***

To ensure the United States remains a world leader in research and education, NSF must maintain an emphasis on funding fundamental, merit-reviewed research across the fields of S&E while paying special attention to potentially transformative research and education. At the same time, the agency must find ways to reach out to the range of communities that play complementary roles in the innovation process and are essential to ensuring the impact of NSF investments.

IV. PLANNING IN A DYNAMIC ENVIRONMENT

The strategic planning process takes place in a dynamic environment. Key challenges manifest in the national and global environment affect the Foundation's ability to fulfill our mission. Some of these challenges present programmatic opportunities in science, engineering, and education, while others affect the expectations held by NSF and our stakeholders for program results.

The **NATIONAL AND GLOBAL ECONOMIC LANDSCAPE** has undergone vast alterations over the past few years. Although the President's Plan for Science and Innovation promises to double NSF's budget by 2017, volatility and uncertainty have had a dramatic impact on the plans for, and the conduct of, research and education in the private and public sectors. Tightening fiscal circumstances exist in many states throughout the nation, and state support for higher education is waning. Faced with enormous pressure to continue profitability, corporations are deferring or foregoing research investments that complement or combine with Federal funding. Research infrastructure, state-level corporate investments in research and education, and economic development partnerships all have unpredictable futures in uncertain economic times. Despite these challenges, NSF must continue to help foster a sustainable and vigorous U.S. research and learning enterprise.

The nation must maintain a **ROBUST SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS WORKFORCE**. Current demographic shifts—particularly, the departure of aging "baby boomer" scientists, engineers, and educators from the workforce—can be expected to impact the future vitality of the nation's technically trained workers. NSF, as a catalyst for positive change in the nation's vast formal and informal education system, and in STEM learning more generally, must contribute significantly to strengthening the future U.S. population working in STEM fields. Tomorrow's STEM workforce must draw on the talents and interests of all sectors of the nation's diverse population. NSF will intensify our efforts to expand participation in the STEM workforce by currently underrepresented segments of the population—women, minorities, and persons with disabilities. We will continue activities that help foster a scientifically literate society, one whose members embrace a new culture of lifelong learning. These efforts will be critical to the continuous invigoration of Americans working in science and technical fields and in other segments of the workforce that support these fields.

Holograms in a Material World

Image credit: Nasser Peyghambarian, University of Arizona

NSF's Engineering Research Centers (ERCs) generate innovation, bridging university research focused on discovery with real-world engineered systems and technology opportunities through partnerships with industry. Researchers at the Center for Integrated Access Networks (CIAN), an NSF ERC headquartered at the University of Arizona (UA), Tucson, have developed a holographic telepresence system that can transmit a series of 3-D images in near-real-time. This image recorded with the system shows three perspectives of one of the researchers. The work is expected to lead to real-time holographic videoconferencing. Lead author Pierre-Alexandre Blanche and his colleagues from UA and Nitto Denko Technical Corp. of Oceanside, CA, described the breakthrough in the cover story of the November 4, 2010, issue of *Nature*. According to Blanche, who is an assistant research professor in UA's College of Optical Sciences, the heart of the system "is a screen made from a novel photorefractive material, capable of refreshing holograms every two seconds, making it the first to achieve a speed that can be described as quasi-real-time." "This advance brings us a step closer to the ultimate goal of realistic holographic telepresence with high-resolution, full-color, human-size, 3-D images that can be sent at video refresh rates from one part of the world to the other," said co-author and project lead Nasser Peyghambarian of UA and the director of the multi-institution CIAN ERC. Read more about it.

NSF must take into account the international opportunities and challenges presented by the **DYNAMIC GLOBAL RESEARCH AND LEARNING ENVIRONMENT**. The rapid evolution in S&E capabilities worldwide is one of the significant trends highlighted by the National Science Board (NSB) in its report, "Science and Engineering Indicators 2010." Among the findings: S&E activities are occurring in more countries as governments recognize that investments in R&D lead to economic growth, employment, and the improved well-being of their citizens, and as industries become increasingly global. In partnership with key stakeholders, NSF will work to assure U.S. leadership in advancing S&E research and education to address global grand challenges. We will enable U.S. researchers and students to leverage increasing worldwide capabilities and investments by facilitating access to internationally located expertise, facilities, and data. NSF is admired, and often emulated, by other nations. As other countries implement formal programs to attract STEM students and advanced degree holders, NSF must play a significant role in maintaining the high quality research environment that has made the United States the destination of choice for the world's top S&E brainpower for many years. In addition, NSF must enable this country's research and education enterprise to take full advantage of the world's best minds, wherever they are found.

The revolution in information and communications technologies is another major factor influencing the conduct of 21st century research. New cyber tools for collecting, analyzing, communicating, and storing information are transforming the conduct of research and learning. One aspect of the information technology revolution is the "**DATA DELUGE**," shorthand for the emergence of massive amounts of data and the changing capacity of scientists and engineers to maintain and analyze it. At the same time, the emergence of web-based social networking tools has increased both the availability of "open" content (ranging from data to peer-reviewed papers, wikis, and software), and the mechanisms for public participation in science. Never before has the research community seen such challenges or opportunities. From the social sciences to the life sciences to the physical sciences to education, vast amounts of data are being collected, transmitted, stored, and processed in new ways, and they are transforming how scientists, engineers, and educators approach complex problems. To meet these challenges, NSF will continue to support the creation of new algorithms, software, and networking and storage capabilities, as well as the development of tools to ensure appropriate security and privacy protocols. Developing a workforce equipped to carry out scientific investigations in an open-access, data-intensive world will be critical to maintaining the integrity of

the enterprise. NSF will also partner with others in the U.S. research and education community, and with science and engineering institutions overseas, to develop data management and access policies. As we build on earlier investment strategies—NSF played a major role in establishing current capabilities for computation and networking in research—we will address emerging challenges and take full advantage of the transformational possibilities they present.

V. STRATEGIC GOALS AND PERFORMANCE GOALS

Three interrelated strategic goals—**Transform the Frontiers, Innovate for Society**, and **Perform as a Model Organization**—grow from NSF's mission and our expectations for leadership and excellence in carrying out that mission. These goals provide the programmatic and operational underpinning for all NSF programs and activities, and they apply to the entire portfolio spanning research, education, and infrastructure. These strategic goals stem from important NSF-related legislation, national priorities, and NSB reports, including "Science and Engineering Indicators," and are set in the context of the broad and balanced NSF portfolio that is critical to promoting the progress of S&E. In addition, numerous reports from NSF advisory committees, the National Research Council, and others support the need for NSF to focus on these key areas.

Each of the three strategic goals has a set of performance goals that provide NSF with a clear set of priorities over the life of the strategic plan. As required by the Government Performance and Results Act, these priorities are revisited every three years and updated as needed. The plan includes specific targets and actions NSF will take to address each target. In many instances, it will be necessary for NSF to establish specific measures and assessment methodologies to determine the extent to which the target has been met over the life of the plan. In addition to the actions specifically identified in this plan, NSF will engage in numerous other actions to support each performance goal. NSF will seize opportunities to innovate, creating a dynamic organization that advances our mission and is responsive to S&E community.

The strategies and means for accomplishing these goals are discussed in Section VI. Our multipronged approach to evaluating and assessing the impact over the life of the plan is discussed in Section VII.

TRANSFORM THE FRONTIERS

Transform the Frontiers emphasizes the seamless integration of research and education as well as the close coupling of research infrastructure and discovery.

Methane Leak

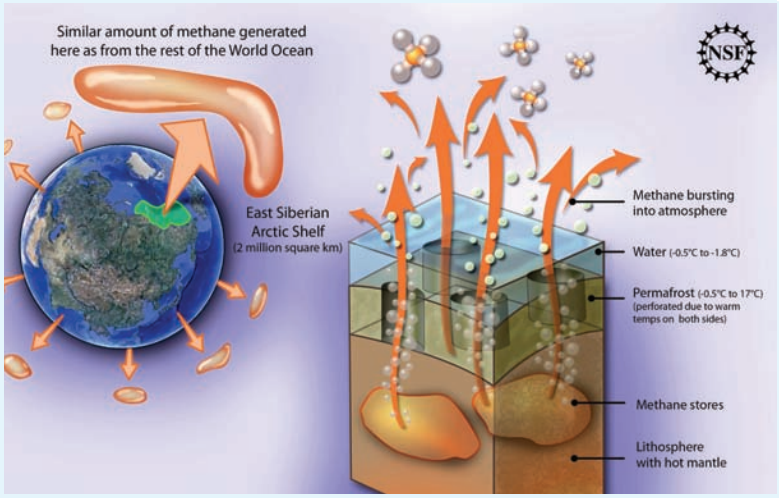


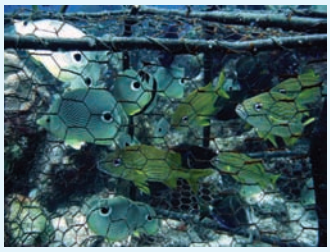
Image credit: Zina Deretsky, National Science Foundation

An international research team led by University of Alaska Fairbanks (UAF) scientists Natalia Shakhova and Igor Semiletov has found that the permafrost under the East Siberian Arctic Shelf, long thought to be an impermeable barrier sealing in methane, is perforated and is leaking large amounts of methane into the atmosphere. Methane is a greenhouse gas more than 30 times more potent than carbon dioxide. "The amount of methane currently coming out of the East Siberian Arctic Shelf is comparable to the amount coming out of the entire world's oceans," said Shakhova, a researcher at UAF's International Arctic Research Center. The study was partly funded by NSF. The Arctic, and the Antarctic, are premier natural laboratories whose extreme environments and geographically unique settings enable research on phenomena and processes not feasible elsewhere. NSF's Office of Polar Programs is the primary U.S. supporter of fundamental research in the Polar Regions. Read more about it.

Preserving Coral Reef Fish Populations

Image credit: Ayana Johnson, Scripps Institution of Oceanography, UC San Diego

NSF's Integrative Graduate Education and Research Traineeship (IGERT) program is establishing innovative new models for graduate education and training in collaborative research environments. Juvenile and narrow-bodied fish species are neither desired by fisherman nor desirable as food, but these fish frequently get caught in a type of trap used on coral reefs throughout the world. Graduate student Ayana Johnson of the University of California at San Diego (UCSD) has found that a simple, inexpensive modification to fish traps could have an enormous impact on preserving coral reef fish populations. Johnson participated as an associate in the IGERT program on marine biodiversity at UCSD. Led by principal investigator Richard Norris, the interdisciplinary program focuses on training U.S. doctoral candidates in understanding the variety of natural and human forces that lead to change in marine ecosystems and loss of biodiversity, and developing policy options for protecting and restoring them. Johnson tested coral reef fish traps that included a small (2.5 x 20 centimeters) gap and found that they allow the smaller fish to escape and reproduce, and in the case of the juveniles, grow to a marketable size. She was inspired by an ordinance recently proposed in Curacao, a small island in the southern Caribbean, that would require all fish traps to include an escape gap. Johnson's research showed that fishermen using the traps with escape gaps caught fewer fish than those using traps without escape gaps, but their yield of saleable fish was the same. The impact on coral reef fish populations could be significant. Johnson found that a trap with a gap catches, on average, 6.3 fewer fish than one without a gap. Retrofitting 10,000 traps (a conservative estimate of the number of active traps in the Caribbean), each of which is used about 100 days of the year, could reduce unwanted catches by 6.3 million fishes each year. Read more about it.



NSF creates opportunities to expand and shape the frontiers of human knowledge. The Foundation embraces our unique role in supporting the fundamental, interdisciplinary, high-risk, and potentially transformative research and education that are central to the discovery of emergent properties and structures in physical, living, human, and engineered systems. NSF enables research at the frontiers by providing state-of-the-art infrastructure, by educating and preparing a diverse, world-class STEM workforce, and by partnering with others nationally and internationally. By transforming the frontiers, NSF can best promote the progress of science, engineering, and education. This bold research agenda encourages high-risk/high-reward activities and pursues potentially transformative ideas, in keeping with recent mandates from NSB[2], Congress[3], and the Executive Office of the President[4].

2 "Enhancing Support of Transformative Research at the National Science Foundation," National Science Board, 2007 (www.nsf.gov/pubs/2007/nsb0732/nsb0732.pdf)

3 America COMPETES Act, 2007 (Public Law 110-69).

4 Office of Management and Budget (OMB)/ Office of Science and Technology Policy (OSTP) Science and Technology Priorities for the FY 2012 budget, July 21, 2010.

PERFORMANCE GOALS

T-1: Make investments that lead to emerging new fields of science and engineering and shifts in existing fields.

Potentially transformative research is a major focus of recent legislation, the Administration's priorities, and the NSB report, *Enhancing Support for Transformative Research at NSF*. Transformative research leads to the emergence of new fields and/or extraordinary shifts in existing fields and, by its nature, has significant impact on the frontiers of S&E, and on improvements in education. And, transformative research leads to important new discoveries.

While NSF's entire portfolio contributes to transforming the frontiers, the Foundation is committed to including in our portfolio a subset of research projects that hold unusual potential for transformative outcomes. To address this long-term performance goal, NSF will:

- Invest in challenging, potentially transformative research,
- Sharpen the merit-review process to better identify such research, and
- Emphasize interdisciplinary and system-oriented approaches that often lead to transformational concepts.

At the same time, NSF, in partnership with other Federal agencies and with counterpart funding agencies in other countries, will explore ways to describe both the portfolio and its outcomes to highlight the emergence of new fields and significant change within existing fields in order to assess progress toward reaching this performance goal.

TARGET

The NSF portfolio fully incorporates emerging areas with transformative potential, including those forming at disciplinary boundaries

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Review FY2010 potentially transformative research methodologies • Identify FY2011 baseline for potentially transformative research and interdisciplinary research funding	• Conduct preliminary assessment of outcomes using Committee of Visitors (COVs), STAR METRICS, and other available tools • Develop new modes of attracting and funding relevant proposals	• Conduct assessment against established metrics including possible changes in the "map of science" over time and program highlights

T-2: Prepare and engage a diverse STEM workforce motivated to participate at the frontiers.

Transforming the frontiers requires scientists and engineers who are trained and motivated to tackle the difficult challenges of working in uncharted territory. Throughout our history, NSF has been the agency charged with ensuring the nation's capacity to generate the workforce needed to meet these challenges. NSF's primary approach to addressing this performance goal is the integration of research and education. Thus, the development of talented young people includes connection to the frontiers of knowledge and direct experience in the conduct of research in the U.S. and in other countries. The Foundation promotes inquiry-based instructional practices and ongoing research on the process of learning and the practice of education to improve the nation's capacity to draw in and retain students in STEM fields, including students from underrepresented groups and institutions. All of these research-oriented programs seek to ensure a healthy balance of new investigators, broad participation from throughout the S&E community, and support for students and postdoctoral researchers involved in research projects. The outcome of these efforts will be an expanded, more inclusive STEM workforce engaged in transforming the frontiers.

TARGET

NSF STEM workforce development programs, models, or strategies have rigorous evidence about the impact on diversity and innovation in the workforce

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Develop data infrastructure to track career trajectories of students, postdoctoral researchers, principal investigators (PIs), and Co-PIs • Share learning and expand effective practices among NSF programs focused on broadening participation	• Pilot mechanisms for tracking career trajectories of students and postdoctoral researchers in programs providing direct student support and programs aimed at broadening participation and design longitudinal studies • Identify best practices for broadening participation at NSF-supported institutions	• Implement mechanisms for tracking career trajectories of students and postdoctoral researchers supported through NSF awards • Implement longitudinal studies using effective assessment tools and tracking information • Use findings on institutional practices for broadening participation to inform program management

T-3: Keep the United States globally competitive at the frontiers of knowledge by increasing international partnerships and collaborations.

The NSB describes the rapidly changing global nature of the S&E enterprise in its report, "Globalization of Science and Engineering Research: A Companion to Science and Engineering Indicators 2010." This performance goal acknowledges that international engagement will be critical to keeping the United States globally competitive at the frontiers of knowledge, while recognizing the need to focus NSF's efforts on those international partnerships and investments that will have the greatest S&E impact. As S&E expertise and infrastructure advance across the globe, it is expected that the United States will increasingly benefit from international collaborations and a globally engaged workforce leading to transformational S&E breakthroughs. Therefore, NSF will promote cooperation among scientists and engineers from all nations and encourage funding of international collaborative activities through all of our programs, relying on the merit review process to assess the added value of proposed international activities in advancing research and education objectives and infrastructure. NSF also will work with our counterpart funding agencies in other countries to lower barriers to collaboration for our scientists, engineers, and students, and encourage jointly funded, bilateral, and multilateral projects.

TARGET

NSF programs increasingly establish international partnerships that advance the frontiers of knowledge

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Conduct baseline assessment of the number and types of international partnerships • Experiment with new modalities for supporting international collaboration	• Implement new modalities based on results of near-term actions	• Conduct assessment based on established metrics and methodology

What Makes Humans Human?

Image credit: Vanessa Woods, Department of Evolutionary Anthropology, Duke University

NSF-supported researchers are advancing understanding of human development in areas such as cognition and social skills. The two closest living evolutionary relatives to humans are the well known chimpanzee and the little known bonobo. With support from NSF, Brian Hare, assistant professor of evolutionary anthropology at Duke University, and colleagues are studying bonobos and chimpanzees to learn if their development can shed light on the developmental origins of human cognition. Hare spends several months of the year in the Democratic Republic of Congo, where he studies bonobos. He focuses on their behavior, specifically on how they solve problems and interact with other bonobos. In a recent paper, he and his colleagues described how bonobos enjoy sharing food with other bonobos, and never outgrow their willingness to do so—unlike chimpanzees, that become more selfish when they reach adulthood. "The study, published in *Current Biology*, is a great example of how experiments are important to understand the psychology of animals," Hare said. The work is also funded by the European Research Council. Read more about it.

T-4: Enhance research infrastructure and promote data access to support researchers' and educators' capabilities and enable transformation at the frontiers.

A major element in the ability to expand S&E knowledge in general, as well as transform the frontiers, is having tools that enable new capabilities for measurement, observation, manipulation, and experimentation. Since NSF's inception, we have developed and maintained forefront infrastructure capability for the broad academic S&E community in coordination with other research agencies. Investments in various multi-user research facilities such as vessels, astronomical observatories, particle accelerators, the U.S. Antarctic stations, seismic observatories, and many others comprise a significant fraction (approximately 15 percent) of NSF's portfolio. Additional components of the infrastructure portfolio include large datasets based on NSF-supported surveys, the provision of shared-use equipment for academic researchers, and interdisciplinary centers. The advent of widespread use of computational and communications capabilities across all S&E fields, and in STEM education, has made cyberinfrastructure, including its easy access and use, a vital element of tools and capabilities provided by NSF.

The Foundation aims to develop and maintain infrastructure that enhances researchers' and educators' capabilities and productivity through management that accounts for and demonstrates best practices. Key to achieving this performance goal will be partnering with other agencies for coordination or exploring opportunities to make complementary investments, working with academic institutions seeking to enhance capability for their faculty and students, and with international partners in situations where complementary investments enhance infrastructure capability or where no one organization can bear the full cost. NSF also brings the concept of broadening participation to infrastructure, ensuring that diverse students and faculty at all types of institutions throughout the nation have access to the infrastructure.

TARGET

NSF prioritizes and manages facility investments throughout their life-cycle in a transparent and effective way

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Continue the measurement and reporting of construction performance for NSF major multi-user facility projects • Introduce requirements for goal setting, measurement and results reporting by operations awardees of major multi-user facilities	• Evaluate operational performance goals and metrics of NSF major multi-user facilities • Develop metrics for evaluating utilization and broadening participation of facilities • Extend the dissemination of best practices and lessons learned on NSF's large facilities to smaller facility programs	• Commission an external study on NSF's stewardship of facilities as a follow-on to the 2004 National Research Council ("Brinkman") report

TARGET

Ensure data generated by NSF's major multi-user facilities are widely accessible to the research community

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Examine data management and cyber-infrastructure challenges associated with selected major multi-user facilities	• Explore mechanisms for increasing the use of facility-generated data by the research community • Identify data management best practices for other NSF-supported research infrastructure	• Assess NSF data management policies against those of other U.S. government agencies and internationally

INNOVATE FOR SOCIETY

Innovate for Society points to the tight linkage between NSF programs and societal needs, and it highlights the role that new knowledge and creativity play in economic prosperity and society's general welfare.

By forging links between fundamental research and society's needs, NSF helps articulate important new areas of S&E, improves quality of life, creates a scientifically literate populace, and empowers future generations. NSF is committed to creating connections between research produced through our investments and the needs of society. This goal requires close interaction with NSF stakeholders, a clear recognition of the Foundation's role in the nation's innovation enterprise, and an appreciation of the dynamic global context. Through this strategic goal, NSF advances the welfare and prosperity of the nation.

PERFORMANCE GOALS

I-1: Make investments that lead to results and resources that are useful to society.

NSF's mission speaks to addressing societal needs; thus, the Foundation looks for ways to link the results of fundamental research and resources derived from this research to national and global policy areas in which S&E can play a significant role. NSF's longstanding commitment to addressing societal needs is largely achieved through investments at the frontiers, in efforts in education, and by partnerships. Engaging stakeholders directly in identifying key societal needs and ensuring communication about those needs with NSF staff involved in program planning and development and with investigators conducting relevant work are critical to addressing this performance goal. While the primary focus of NSF-supported research is the generation of new knowledge, NSF programs, where appropriate, consider stakeholder input to optimize the utility of research to address societal needs.

Partnerships catalyzed between academia, industry, and the government throughout the U.S., and around the globe, shape NSF programs. NSF creates strategic collaborations with other agencies, academia, and the private sector to enable the translation of fundamental research to usable contexts as rapidly as possible. The Foundation regularly matches investigators with potential users of the outcomes of research through programs, workshops, and other means. NSF also establishes long-term relationships with industry and other agencies through memoranda of understanding (MOUs), Letters of Agreement, and joint announcements.

TARGET

NSF investments underpin long-term solutions to societal challenges such as economic development, climate change, energy, and cyber-security

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Expand partnerships and collaborations with industry or government agencies in identifying areas of critical national need • Pilot models for investing in priority areas having societal impact	• Issue solicitations and Dear Colleague Letters in areas of critical national need	• Conduct impact assessment of portfolio investments in areas of national need

I-2: Build the capacity of the nation's citizenry for addressing societal challenges through science and engineering.

Building human capacity to address societal needs requires attention to the preparation and continued learning of tomorrow's STEM workforce as well as attention to STEM literacy for the public at large. NSF is committed to reaching across society to ensure that the rich diversity of the nation's cultures is well represented in the STEM workforce and that individuals engaged in STEM fields are trained to participate fully in the global research enterprise. These efforts will expand our capacity for synergy—simultaneously bringing the country's range of intellectual power and cultural perspective to bear on the most challenging problems. A growing body of research in learning and STEM education serves as the basis for guiding NSF programs and creating the links among schools, community colleges, colleges and universities, workplaces, and informal education mechanisms that are critical to workforce preparation and STEM literacy.

The scientific literacy of society is central to the progress of science and is a necessary backdrop for innovation. Given the complex and technical challenges that society faces, ranging in scope from personal to global, it is vital that resources and opportunities for continued access to cutting-edge science are broadly available.

TARGET

NSF's scientific literacy and public engagement programs are supported by rigorous evidence about learning outcomes

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Develop an NSF-wide assessment framework for activities addressing public understanding and communication of science and engineering	• Establish new focus in NSF programs for life-long learning • Develop data collection protocols for NSF-wide assessment framework	• Conduct assessment to determine if NSF-funded projects are producing evidence-based models that demonstrate impact on learning and interest in science with a wide range of audiences

TARGET

NSF's K-12 STEM education investments are designed and tested for scale-up

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Develop standards of evidence needed to position education innovations for scale-up	• Generate data on implementation of programs developing curricula and resources that enhance multiple disciplinary perspectives on addressing national challenges	• Conduct an assessment to determine if there is a body of evidence to support scale-up and wider implementation of NSF-funded projects

I-3: Support the development of innovative learning systems.

Technologies are already deeply entwined with people's lives, especially the lives of young learners. Fully embracing such technologies as learning tools in the nation's classrooms and laboratories, and living rooms and libraries, is part of innovating for society. Science itself is being transformed through networked computing and communications technologies. Networked computing and communications technologies that support learning, teaching, and education are already opening up access for all learners, in all age groups, in all settings.

Innovative learning systems can bring authentic scientific data immediately to learners, which enable learners to experience science through modeling, simulation, sensor networks, digital telescopes and remote instruments. Technology has the potential to transform science learning as effectively as it has transformed science itself. Learning can occur anytime, anywhere, and for anyone.

TARGET

NSF invests in innovative learning tools and structures that use emerging technologies and are tested for effectiveness and scalability

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Expand initiatives across NSF to develop research-based innovative learning systems	• Investigate anytime, anywhere, model learning systems and tools	• Assess impacts of early models on learning

TARGET

New partnerships among scientists, engineers, and educators (both theorists and practitioners) take innovations from development to practice

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Promote partnerships among computer scientists, other STEM disciplinary scientists, learning scientists, and education practitioners to catalyze new technologies for learning	• Establish multidisciplinary teams to support K-12 teacher education including projects exploring how to maximize teacher expertise in exploiting new tools	• Assess whether cyberlearning is recognized and supported as a field of investigation • Assess effectiveness of and adoption of cyberlearning approaches

Stuck on You

Researchers from Purdue University and the University of South Carolina have discovered how oysters bond together to form massive reef complexes. Studying the common Eastern oyster (*Crassostrea virginica*), the researchers found that the oysters produce a unique adhesive material for affixing themselves to each other, a cement that differs from the glues used by other marine organisms. "Such knowledge can help us develop biomedical materials including wet setting surgical adhesives. These insights may also help us prevent marine bio-adhesion for keeping ship hulls clean, thereby reducing drag, fuel consumption, and carbon emissions," said Purdue chemist Jonathan Wilker, one of the study's lead researchers. Read more about it.

Image credit: Jonathan Wilker, Purdue University

PERFORM AS A MODEL ORGANIZATION

Perform as a Model Organization emphasizes the importance to NSF of attaining excellence and inclusion in all operational aspects.

NSF sets high standards for performance and integrity in support of our mission and in enabling our workforce to carry out activities efficiently, effectively, and sustainably. The Foundation promotes a culture of excellence that encourages diversity, creativity, and initiative. NSF is committed to broadening participation. This is reflected in our recruitment and selection of reviewers and panelists as well as the selection and empowerment of staff. We implement first-rate administrative, financial, information technology, and infrastructure systems that support individual staff members and provide high-quality customer service to the public. NSF aspires to be a learning organization that aims for continual improvement in our processes and continual development of our people. NSF is committed to the principles underlying open government including transparency, participation, and collaboration, and to translating this commitment into action. NSF serves as a model for other organizations that fund research and education and takes a leadership role in cross-agency activities.

PERFORMANCE GOALS

M-1: Achieve management excellence through leadership, accountability, and personal responsibility.

When the people who comprise NSF—career staff, rotators, and contractors—clearly understand their roles and responsibilities in service to the agency's mission, NSF will be at its best as an effective, efficient organization. Therefore, communicating clear standards and expectations is part of an ongoing conversation within NSF, engaging those involved in research programs and in agency administration, and aimed at generating a results-oriented performance culture. It is particularly important that NSF management be held to the highest standards to reflect NSF's commitment to performance excellence. It is the responsibility of each manager to provide an operational environment that promotes integrity, creativity, and fiscal accountability.

New NSF managers will be integrated into the agency through mandatory elements of the New Executive Transition (NExT) program, mentoring, and executive coaching. NSF will build on lessons learned from the experiences of all staff, including our rotators who bring fresh ideas and viewpoints. NSF has a major commitment to diversity and fair treatment of all current and prospective employees and is taking action necessary to become a model Equal Employment Opportunity (EEO) agency.

TARGET

More effective management enables all staff to understand how their duties support the mission of the Foundation

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Review current performance management system and initiate expansion of coverage of Senior Executive Service (SES) and General Workforce (GWF) performance management to rotating staff • Increase use of feedback mechanisms to continuously improve management leadership skills and accountability, defining baselines where appropriate • Initiate process to attain status as a model EEO agency as defined by the U.S. Equal Employment Opportunity Commission (EEOC)	• Develop plan to improve the performance management system • Assess impact of expanding coverage of performance management framework to rotating staff • Implement action plan for employee engagement to address employee feedback • Assess progress toward model EEO status	• Assess implementation of the plan to improve the performance management system • Use continuing feedback mechanisms to assess progress for employee engagement plan. Refine plan, as needed

Evolution Chain Reaction

Image credit: Rob Oakleaf

NSF supports research that advances the frontiers of knowledge in the life sciences by increasing our understanding of complex living systems. New insights into biodiversity and evolutionary dynamics could prove crucial to environmental sustainability. A team of researchers is studying the ongoing emergence of a new species of fruit fly—and the sequential development of a new species of wasp. Jeff Feder, a University of Notre Dame biologist, and his colleagues say the introduction of apples to America almost 400 years ago ultimately may have changed the behavior of a fruit fly, leading to its modification and the subsequent modification of a parasitic wasp that feeds on it. Pictured above, a female apple maggot fly, *Rhagoletis pomonella*, implants an egg into an apple. Wasps that attack and eat the flies' larvae appear to be changing on a genetic level as the flies change genetically. "It's a nice demonstration of how the initial speciation of one organism opens up an opportunity for another species in the ecosystem to speciate in kind," said Feder. "Biodiversity in essence is the source for new biodiversity." Read more about it.

M-2: Infuse learning as an essential element of the NSF culture with emphasis on professional development and personal growth.

NSF stresses personal learning and development to enhance performance, further our knowledge base on all aspects of NSF activity, and continue to build for the future. For example, NSF fosters personal responsibility for professional growth through use of Individual Development Plans (IDP) and Independent Research and Development (IRD) Plans

across the agency, while expecting managers to provide needed guidance on the development of such plans. NSF reinforces this effort by investing in staff education and learning resources (e.g., Program Manager Seminars, Embassy Science Fellows, AcademyLearn, policy "town hall" meetings, certification programs, on-line courses) as well as targeted development opportunities to upgrade skills and knowledge of all staff as individuals and as members of teams working toward common objectives. Each manager will work with his or her staff to promote learning as the foundation of NSF's performance culture.

TARGET

NSF emphasizes learning for personal and professional development for all staff

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Establish effective practices for assessing and addressing developmental needs of NSF staff	• Establish priorities for resource use in closing identified gaps in NSF learning portfolio	• Assess NSF learning portfolio and effective use by NSF staff
• Review current NSF learning opportunities and develop a plan for addressing gaps	• Review on-boarding program using employee feedback to plan for improvement	• Evaluate effectiveness of supervisors' and employees' use of assessment capabilities and learning portfolios to create individual development plans.
• Establish comprehensive on-boarding procedures appropriately tailored to position		

Engineering K-12 Education

Image credit: Elsa Head, Tufts University

NSF invests in projects that encourage future generations of scientists and engineers and revitalize the nation's science, technology, engineering, and mathematics (STEM) educational pipeline. Chris Rogers at Tufts University is working to improve science education by bringing engineering into K-12 classrooms. He and his colleagues have found that teaching engineering early is important because the engineering principles of building and designing to solve problems motivates young students to pursue science and math. When he started, there were few studies of the benefits of introducing engineering to the K-12 curriculum. To change this, Rogers started the Center for Engineering Education and Outreach (CEEO) in the School of Engineering at Tufts. The Tufts' Student Teacher Outreach Mentorship Program (STOMP) was one of the center's first efforts. STOMP enlists undergraduate engineering students to mentor K-12 teachers and students, like these fifth-grade students in Arlington, MA, using activities focused around engineering. A core principle behind STOMP is that all elementary school students are capable of learning engineering concepts and that those concepts can be built on throughout the years. One measure of the program's success is the fact that it has grown to include nearly 10 universities that have STOMP outreach programs, connected via the STOMP network. Now, Rogers and his CEEO colleagues are developing and testing curriculum materials for introducing engineering concepts in grades 3 through 5. Read more about it.

M-3: Encourage and sustain a culture of creativity and innovation across the agency to ensure continuous improvement and achieve high levels of customer service.

While NSF supports potentially transformative research through our grant programs, we also promote *internal* institutional transformation through creativity and innovation. Currently, NSF is taking a new and novel approach to become a model Federal steward with regard to environmental responsibility and sustainability. In the continued

transition to fully electronic business processes, we are transforming the processes underlying our proposal decision and award actions. NSF is working to improve internal administrative processes on a continuing basis to provide efficient, effective service for all NSF staff. The current NSF headquarters' lease expires in December 2013. The *Future NSF* project is tasked with ensuring NSF's core mission and the business of the agency are expressed and supported by the design and function of the future NSF headquarters.

NSF's success as a world-class, grant-awarding institution is dependent on the business processes, both programmatic and administrative, that support the agency each and every day. NSF continues to maintain a leadership role in Federal grants management in service to research and education constituencies. NSF is committed to standardization and streamlining of Federal systems that interface with the grantee community, so that our grantees can operate their business systems accountably and efficiently. Through continued development of Research.gov, NSF is exploring creative mechanisms to be even more transparent and accountable to the research community and the American public. NSF also pursues strategies that strengthen accountability efforts of the awardee community through business assistance and reporting tools. In addition, NSF is taking steps to improve contract management and oversight throughout all acquisition phases.

NSF applies a spirit of experimentation to its own business processes. This is aimed both at making the organization more efficient and effective as well as stimulating creativity in the research and education activities we support. This commitment is a defining element of this plan, and it will be visible in numerous ways over the next five years. Examples of this experimentation include innovative approaches to the facilitation and review of proposals for NSF funding, such as "blind reviews" and "grade-free" panels, "Ideas Labs" that incorporate creative problem-solving techniques and real-time collaborations to identify the most pressing challenges and questions in science and engineering research and education, and continued investment in leading-edge technologies and capabilities for NSF business systems and processes.

TARGET

NSF uses the innovation and creativity of our staff to improve agency processes and systems on a continuing basis

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Establish plan for periodic assessment of primary NSF business processes and systems • Revitalize system for taking employee input into consideration in improving business processes and systems • Plan for upgraded financial system	• Conduct periodic assessments of primary business processes and systems based on established metrics • Plan for new processes and systems based on employee input • Implement upgraded financial system	• Review effectiveness of periodic assessment • Assure upgraded financial system meets NSF needs and Federal requirements

TARGET

NSF organizations achieve high levels of customer satisfaction

NEAR-TERM ACTIONS	MID-TERM ACTIONS	LONG-TERM/ASSESSMENT
• Develop a range of mechanisms, including use of current IT capabilities and open government/social media platforms, to obtain information on customer satisfaction on behalf of both internal and external customers • Explore methods to increase participation rates for respondents of NSF customer satisfaction activities	• Develop action plans to address areas of improvement identified by customer satisfaction information	• Assess customer satisfaction on a continuing basis and develop or refine action plans, as needed

Thermopower Waves From Carbon Nanotubes

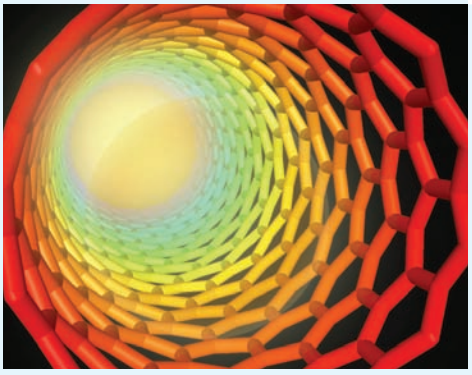


Image credit: Christine Daniloff

NSF's contribution to the multiagency National Nanotechnology Initiative 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. A nanometer is one-billionth of a meter. A team of scientists at the Massachusetts Institute of Technology (MIT) has discovered a previously unknown phenomenon that can cause powerful waves of energy to shoot through miniscule wires known as carbon nanotubes (depicted in this illustration). The discovery, described as thermopower waves, opens up a new area of energy research, according to Michael Strano, MIT's Charles and Hilda Roddey Associate Professor of Chemical Engineering who was the senior author of a paper on the research in *Nature Materials* on March 7, 2010. Strano and colleagues found that a thermal wave—a moving pulse of heat—travelling along a microscopic wire can drive electrons along, creating an electrical current. In the group's experiments, the amount of power released is much greater than that predicted by thermoelectric calculations, Strano said. While many semiconductor materials can produce an electric potential when heated—through something called the Seebeck effect—that effect is very weak in carbon. Strano said something else is happening in their experiments. "We call it electron entrainment, since part of the current appears to scale with wave velocity." Practical applications for the discovery could include enabling new kinds of ultra-small electronic devices for sensors injected in the body or environmental sensors that could be scattered in the air. Read more about it.

VI. STRATEGIES AND MEANS

Meeting the challenges of our mission, vision, and strategic goals requires NSF action across many dimensions. This includes core strategies that underpin program planning and implementation and means that are routinely used to implement our core strategies.

CORE STRATEGIES

NSF fulfills our mission through the following core strategies:

- *Be a leader in envisioning the future of science and engineering.* NSF exhibits leadership through our constant interaction with the S&E community we support, the Federal government of which we are a part, and the international agencies that we work with. These interactions include continually probing for ideas that can change the face of S&E, taking risks that have the potential for high pay-off, providing opportunities for the development of new ways to measure, observe, and experiment, and encouraging connections across disciplines and geographic boundaries.
- *Manage investments using a portfolio approach.* A balanced portfolio of investments in research and education requires NSF program staff to fund activities across S&E, including both disciplinary and interdisciplinary projects; use multiple modes of funding ranging from awards to individual investigators to large centers and facilities; accept unsolicited proposals from the community and design effective solicitations to accomplish specific objectives; use multidimensional criteria for funding decisions based on intellectual merit and broader impacts; and embrace risk while remaining accountable.
- *Integrate research and education and build capacity.* NSF develops research and education capacity across the full spectrum of the nation's educational institutions through direct support for research, education, and infrastructure, and through the broader impacts that flow from this support to transform the way people learn throughout their lives, teach in formal and informal settings, and prepare the next generation of scientists and engineers.
- *Broaden participation.* NSF focuses on broadening participation of groups, institutions, and geographic regions underrepresented in STEM disciplines, working with academic and private sector partners to make certain that STEM education and workforce preparation, infrastructure, and research opportunities are broadly available to ensure that the technical workforce and scientists and engineers have the skills and opportunities needed to flourish in a global knowledge economy.
- *Learn through assessment and evaluation of NSF programs, processes, and outcomes; continually improve them; and employ outcomes to inform NSF planning, policies, and procedures.* NSF's commitment to excellence

Conducting Field Work Around the Globe

Image credit: Essa Gross, Michigan Technological University

Recognizing that scientific discovery is a global enterprise, NSF encourages international collaboration and helps U.S. scientists, engineers, and students engage in activities that advance knowledge and apply science and engineering in response to societal needs, wherever they arise. An NSF Partnership for International Research and Education (PIRE) award to Michigan Technological University (MTU) enabled the institution's scientists, engineers and students to work with collaborators in Nicaragua, Guatemala, El Salvador, and Ecuador on developing remote-sensing tools for hazard mitigation and water resource development. Working with her advisor John Geirke, MTU grad student Jill Bruning sought to identify geological lineaments (fractures) from satellite imagery to improve groundwater exploration and the siting of wells. One challenging part of the fieldwork, she said, involved performing well-pumping tests such as one in a farmer's field near Boaco, Nicaragua. Before they could run pumping tests, Bruning and her colleagues had to gain the community's cooperation; every well the researchers tested had to remain unused for several hours prior to the test. Above right, Bruning (center) enters pumping test data into a spreadsheet while Hans Bruning (also from MTU) fills up buckets. A local farmer and his family watch the process. This particular PIRE has a unique partnership with the Peace Corps Master's International program. Some of the PIRE masters' students are also Peace Corps volunteers; they do one year of course work at MTU, and then serve in the Peace Corps for two years while also conducting their research. Following their Peace Corps service, they return to MTU to write up their theses. Read more about it.

requires that we do all we can do to make programs and processes the best they can be and to provide the best possible outcomes from our investments to the American people. There is a growing body of tools that will allow NSF to enhance our capabilities for assessment and evaluation. NSF is committed to using such tools to learn about ourselves and to modifying activities as appropriate, and to leading the way toward the frontiers in these areas of assessment and evaluation.

MEANS FOR CARRYING OUT CORE STRATEGIES

In addition to evaluation and assessment, which are discussed in the next section, NSF uses the following three basic means to carry out our core strategies:

- *Interaction and partnership with stakeholder communities.* Mechanisms include: support for and participation in workshops and conferences; participation in professional society meetings; advisory committees (ACs) and COVs; involvement in activities of the National Science and Technology Council; bilateral and multilateral interagency activities in areas of interest; partnerships with industry; cooperation with counterpart organizations in other nations; surveys of stakeholder communities; working with or through the committees and boards of the National Academies; and more. These interactions allow NSF to take the pulse of the stakeholder community on an on-going basis and take a leadership role in shaping the directions of S&E, in an open and transparent manner, for the common good.

- *Program-oriented business processes related to development and oversight of the award portfolio.* The key portfolio-oriented business processes are (1) proposal generation; (2) decision making based on merit review; (3) award management and oversight; and (4) results reporting. The first two are processes for shaping the portfolio of awards, and the second two aim at the effectiveness of the portfolio for meeting NSF objectives. As these processes evolve, NSF is better able to carry out our work efficiently and effectively. Critical connections with stakeholder communities influence the outcomes of these processes.

- *Management-oriented business processes.* NSF's management systems sit at the interface of programmatic and internal operations. These processes are critical for translating priorities derived from strategic goals into implementation of programs that permit researchers to advance the progress of S&E. NSF aims to be creative and innovative in implementation, at the same time ensuring that business processes meet Federal policies and standards. Tools include budget development and execution, financial management systems, grants and agreements policies and systems, procurement systems, IT systems of all types, human capital systems, and facilities' operations, including providing the workspaces and conference rooms that are so critical to an interconnected agency.

VII. EVALUATION AND ASSESSMENT

To gauge progress toward NSF's strategic and performance goals, this plan establishes a framework for evaluation and assessment that builds upon longstanding NSF processes and also embraces new approaches. This framework has at its core NSF's tradition of relying on guidance and input from the research and education community—through the merit review process, COVs, the agency's network of advisory committees, and formal reviews and evaluations by external experts.

Merit Review: NSF's approach to merit review is recognized internationally as a best practice for review, assessment, and selection of projects. The merit review process helps assure that awards made by NSF are of the highest quality, are relevant to our strategic goals and objectives, and have an appropriate balance for the resulting portfolio.

Committees of Visitors: Each COV consists of external experts in science and engineering research and education who review actions taken on proposals for one or more NSF programs. COVs conduct detailed reviews of the materials associated with individual proposal actions. They assess the integrity and efficiency of the system for proposal review.

Advisory Committees: Directorates, offices, and some Foundation-wide programs have ACs composed of external experts. ACs not only review COV reports and examine directorate and office responses to COV recommendations, but they also provide advice on priorities and program effectiveness.

Other Reviews and Evaluations: NSF pays careful attention to the advice offered in reports by the National Academies, national and international science organizations, professional societies, workshops, interagency working groups, advisory committees, and the National Science Board. NSF also employs a range of approaches to gain feedback on the efficiency and effectiveness of its systems and processes. Formal approaches include the testing of NSF systems against Federal standards such as those established by the Federal Information Security Management Act (FISMA). Other methods used include periodic surveys of applicants for NSF funding to gauge overall satisfaction, as well as surveys of NSF staff for feedback on NSF's internal services, systems, and working environment.

NEW APPROACHES TO EVALUATION AND ASSESSMENT

In addition to these longstanding inputs and processes, this strategic plan establishes a commitment to innovation and experimentation in the assessment process itself. Over the period of this plan, NSF will test and refine a range of emerging approaches to the assessment of our portfolio of long-term investments in S&E research and education.

This commitment to innovation in assessment reflects a confluence of events surrounding performance assessment and reporting generally and assessing investments in S&E specifically. Across government, there is strong interest in ensuring that performance assessment approaches inform the ongoing management and evaluation of programs and drive continuous improvement in organizations. Toward this end, NSF is included in a government-wide

Image credit: Josh Wurman, CSWR

Chasing Storms

Why do tornadoes form and how can they be more accurately predicted? NSF is a major supporter of research to understand, predict, and respond to tornadoes and other severe weather phenomena. One tool advancing the study of twisters is the Doppler-on-Wheels (DOW), a NSF atmospheric science facility that uses Doppler radar to produce velocity data about objects (such as tornadoes) at a distance. Josh Wurman, director of the Center for Severe Weather Research (CSWR) in Boulder, CO, and colleagues developed the first DOW in 1995. Now there are three. These agile platforms provide a unique ability to obtain up-close, high-resolution views of a variety of extreme atmospheric phenomena. In the springs of 2009 and 2010, Wurman and more than 100 other atmospheric scientists and students joined in a project called VORTEX2 to track tornadoes across tens of thousands of miles from Texas to the Dakotas, Wyoming to Iowa. In the winter of 2011, the DOW was used in and around Oswego, NY, to gather information on lake-effect snowstorms. These winter storms form around the Great Lakes and produce enormous snowfall rates. Research on snowstorms, tornadoes, and other disruptive natural events will provide a better understanding of natural environmental hazards and help improve predictions, which in turn can save lives and minimize property damage. Read more about it.

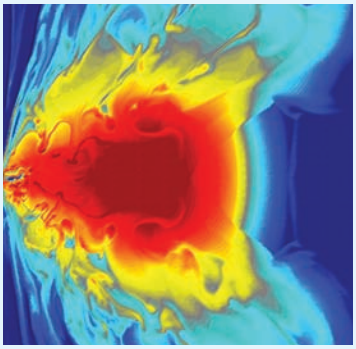


Image credit: John F. Hawley, Kris Beckwith, University of Virginia

Modeling Black Hole Accretion Disks

Accretion disks around black holes power some of the most energetic phenomena observed in the universe. John Hawley and Kris Beckwith of the University of Virginia and their collaborators used NSF-sponsored supercomputing resources, including the National Center for Supercomputing Applications' Abe, to design models to test the influence of different magnetic field configurations on disk and jet formation around a spinning black hole. This image shows the distribution of gas density (colors from blue for low density to red for high density) in a black hole accretion disk simulation. The researchers found that otherwise smoothly orbiting gas in an accretion disk will become highly turbulent in the presence of even relatively weak magnetic fields—something that had been ignored in previous simulations and theories. NSF's support of advanced cyberinfrastructure, including high performance computing systems, data storage systems and repositories, advanced instruments and visualization systems, enables researchers to gain new insights and investigate much larger and more complex research challenges than had been possible previously. Read more about it.

initiative led by the Office of Management and Budget (OMB) and the Council of Economic Advisors to improve overall capabilities for program evaluation.

At the same time, an impressive set of new tools, capabilities, and insights is now available for understanding and describing the dynamics of investments in S&E. Many of them have emerged from NSF investments through the Science of Science and Innovation Policy program. One example of a very promising emerging resource for assessment is the STAR METRICS project (Science and Technology in America's Reinvestment—Measuring the Effect of Research on Innovation, Competitiveness, and Science), which is a partnership between science agencies and research institutions to document the outcomes of science investments to the public. NSF is working with the Office of Science and Technology Policy, the National Institutes of Health, and other agencies of the National Science and Technology Council to develop a common empirical data infrastructure available to all recipients of federal funding and science agencies.

As presented with the performance goals, the underlying assessment framework will rely on multiple measures and metrics applied over different time scales, in keeping with recent recommendations from the NSF Advisory Committee for GPRA Performance Assessment. This is further developed in the table on the next page.

A defining characteristic of this assessment framework is the cyclical nature of the underlying processes. The near-term processes, for example, typically occur on an annual basis and focus on inputs and near-term outputs, addressing questions such as "Was funding awarded on a timely basis? How did this year's reviewer pool compare to last year's? Are we seeing a broader pool of applicants?"

The mid-term activities focus on activities that occur over cycles of roughly 2-5 years, coinciding roughly with the durations of NSF awards. Key factors in this time frame are the initial indicators of whether investments are proceeding as expected. Are construction projects meeting cost and schedule targets? For major investments to facilitate interdisciplinary work, are the necessary collaborations and cross-disciplinary mechanisms being established? Are efforts aimed at broadening participation reaching underrepresented groups and institutions?

Perhaps the most ambitious and experimental parts of this framework are those associated with the long-term time frames. As part of efforts to establish a centralized capability for assessment and evaluation, NSF plans to support retrospective assessments and impact studies of its investments in science and engineering research and education. These assessment activities will draw upon the emerging approaches discussed above, such as the STAR METRICS project and other advances associated with work funded by NSF and other agencies to advance the science of science and innovation policy.

It should also be noted that while this assessment framework focuses principally on NSF programmatic investments, the plan establishes an analogous set of measures and activities for the operational activities associated with the Model Organization goal. For this goal, near- and mid-term activities focus on planning and implementing key changes in NSF's business processes, while long-term activities aim to establish the appropriate reviews, assessments, and surveys needed to inform future decisions and process improvements.

NSF ASSESSMENT FRAMEWORK: TIME FRAMES AND POTENTIAL APPROACHES

NEAR-TERM	MID-TERM	LONG-TERM
TYPICAL TIME FRAMES: • Annual for business process measures • 1-2 years for establishing baselines	**TYPICAL TIME FRAMES:** • 2-5 years • Roughly parallel to durations of NSF awards	**TYPICAL TIME FRAMES:** • 5-10 years • Following the period of NSF investments
OVERALL FOCUS: NSF PORTFOLIO DEVELOPMENT – Portfolio and customer service measures.	**OVERALL FOCUS: NSF PORTFOLIO MONITORING –** Activities to monitor NSF investments and investment strategies.	**OVERALL FOCUS: INVESTMENT, RETURNS, RESULTS, AND OUTCOMES –** Retrospective impact assessments, especially in areas of focused or sustained NSF investment.
• Timeliness (customer service/dwell time) • Key award trends (size, duration, funding rate) • Key broadening participation trends (especially outreach, reviewers, and applicants) • Development/implementation of strategies, initiatives • Use of novel mechanisms in merit review • Planning and baselining	• Financial measures (draw down of funds at expected rates) • Award monitoring (project reports, site visits, principal investigator meetings) • Interim reviews (COV processes) • Project/program-specific measures (construction projects, large-facility operational measures) • Development of partnerships (federal, state, and local agencies; nonprofit and for-profit industry; international governments and businesses)	• Knowledge impacts (new fields, transformation of existing fields) • Economic impacts (overall returns, knowledge transfer across sectors) • People impacts (career trajectories of participants in NSF-supported activities) • Societal impacts (benefits, improvements to quality of life)

SUMMARY: NSF STRATEGIC AND PERFORMANCE GOALS

STRATEGIC GOALS	TRANSFORM THE FRONTIERS	INNOVATE FOR SOCIETY	PERFORM AS A MODEL ORGANIZATION
PERFORMANCE GOALS	• Make investments that lead to emerging new fields of science and engineering and shifts in existing fields. • Prepare and engage a diverse STEM workforce motivated to participate at the frontiers. • Keep the United States globally competitive at the frontiers of knowledge by increasing international partnerships and collaborations. • Enhance research infrastructure and promote data access to support researchers' and educators' capabilities and enable transformation at the frontiers.	• Make investments that lead to results and resources that are useful to society. • Build the capacity of the nation's citizenry for addressing societal challenges through science and engineering. • Support the development of innovative learning systems.	• Achieve management excellence through leadership, accountability, and personal responsibility. • Infuse learning as an essential element of the NSF culture with emphasis on professional development and personal growth. • Encourage and sustain a culture of creativity and innovation across the agency to ensure continuous improvement and achieve high levels of customer service.

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