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on
The President's Fiscal Year 2012 Budget Request
for the National Science Foundation

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Chairman Nelson, Ranking Member Boozman, and Members of the Subcommittee, it is my privilege to be here with you today to discuss the National Science Foundation's fiscal year (FY) 2012 Budget Request. My name is Subra Suresh and I am Director of the National Science Foundation (NSF).

I hope to make a clear and compelling case for the critical value of NSF support for science and engineering research and education at a time when America faces many pressing needs and tight budget constraints. I came to the United States as a young engineering student because it was the world's beacon of excellence in science and engineering research and education. I stayed for the same reason. The mission of NSF is to sustain that excellence as we continue to lead the way for the important discoveries and cutting-edge technologies that will help keep our Nation globally competitive, prosperous, and secure.

The President's request for NSF for FY 2012 is $7.8 billion, an increase of 13 percent, or $894 million, over the FY 2010 Enacted level. *The President's Plan for Science and Innovation* calls for doubling the federal investment in key basic research agencies. NSF's request is consistent with this plan, with the Administration's Innovation Strategy, and with the America COMPETES Reauthorization Act of 2010. The increase will support 2,000 more research awards across the nation.

In FY 2012, NSF will strengthen support for basic research and education in all fields of science and engineering, and promote collaborations that reflect the increasingly interdisciplinary nature of modern science and engineering, while strengthening our disciplinary excellence. We will capitalize on many promising areas of investigation where new discoveries can help establish U.S. leadership in next generation technologies, and we will invest in transformational work, new fields, and novel theoretical paradigms to fuel the innovations of the future. Innovative programs to bolster world-class science, technology, engineering, and mathematics education (STEM), from coast to coast, and from north to south, are central to the success of all these activities.

NSF: Where Discoveries Begin

Sustained federal support for research and education has fueled innovation and provided benefits to the American public for decades, and NSF has played a significant role in this success. For over 60 years, NSF has been a catalyst for the development of new ideas in science and engineering and supported the people who generate them.

In 1952, Caltech professor Max Delbruck used one of NSF's first grants to invent molecular biology techniques that enabled one of his students, James Watson, to determine the molecular structure of DNA. Since then, an entire biotechnology industry has bloomed and prospered, with profits reaching $3.7 billion last year.

In the 1960s and '70s, NSF provided seminal funding for fundamental mathematical and process innovations for manufacturing that industry considered too risky to fund. These led directly to rapid prototyping—and revolutionized how products are designed and manufactured.

In the 1980s, NSF supported the very first computer science departments in U.S. universities, bringing computer science into the mainstream of research, and providing a training ground for the first and subsequent generations of computer scientists and entrepreneurs. Today, NSF provides 82 percent of total federal support for research in computer science conducted in the nation's universities and colleges. Jobs related to computer and information technologies are among the most rapidly growing in the nation according to Bureau of Labor Statistics projections.

In the 1990s, NSF supported pioneering research in the emerging field of nanotechnology. Between 2001 and 2010, NSF-supported centers and networks created 175 start-ups and developed collaborations with over 1,200 companies.

Investments in basic research often yield unexpected benefits as well. NSF's support of game theory, abstract auction theory, and experimental economics provided the Federal Communications Commission (FCC) with its current system for apportioning the airwaves. Since 1994, FCC "spectrum auctions" have netted over $45 billion in revenue for the federal government and more than $200 billion in worldwide revenue.

The NSF FY 2012 Budget Request builds on these past accomplishments and provides a direction for future success. To fuel the innovations of the future, NSF continues to support fundamental research and education in all fields of science and engineering to maintain a global edge in the competition for new ideas and the most talented people. The core science and engineering disciplines form the "building blocks" for future innovations, and provide the new ideas and approaches needed to advance the interdisciplinary research that is a hallmark of contemporary science and engineering. In all these activities, we keep a steady focus on the frontier, where discoveries begin.

The NSF FY 2012 Budget Request

The Administration's *A Strategy for American Innovation* makes clear the larger rationale for investments in science and engineering research and education. This is to put knowledge to work—to create the industries and jobs of the future, and to improve the quality of life and enhance the security and prosperity of every citizen. NSF investments support each of the three pillars of this strategy: *Invest in the Building Blocks of American Innovation, Promote Market-Based Innovation,* and *Catalyze Breakthroughs for National Priorities.*

Invest in the Building Blocks of American Innovation.

A robust U.S. science and engineering research enterprise is necessary to maintain a global edge in the competition for new ideas. In FY 2012, NSF will continue to support the most promising research programs and launch several new initiatives.

Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) will support new activities to encourage investigators to undertake the interdisciplinary research that is a hallmark of much contemporary science and engineering. This effort will be in concert with disciplinary excellence. INSPIRE will catalyze interdisciplinary research by seamlessly integrating a suite of new activities with existing efforts and other NSF investments. The goal is to foster and support the transformative research that interdisciplinary research so often produces. INSPIRE is a new $12 million initiative in FY 2012, and will involve participation from all Directorates.

Science and Engineering Beyond Moore's Law (SEMBL) explores next generation computing, including quantum computing, that addresses the limits of current technology. Those limits may be reached in as few as 10 to 20 years. In FY 2012, NSF will invest $96 million to continue this multidisciplinary program.

Research at the Interface of the Biological, Mathematical, and Physical Sciences (BioMaPS) is a $76 million investment to investigate biological systems that provide architectural and operational blue prints which can guide engineering of adaptive technologies. BioMaPS will integrate research in the biological, engineering, mathematical, and physical sciences to better understand and replicate nature's ability to network, communicate, and adapt. The research will accelerate the generation of bio-based materials and sensors, and the advanced manufacturing of bio-inspired devices and platforms.

Global leadership also requires the most knowledgeable and skilled STEM workers in the world. NSF's approach is to develop the nation's talent pool by integrating research and education. This longstanding NSF practice facilitates the direct transfer of new knowledge to the private sector. It happens every time graduate students with experience working at the frontiers of discovery enter the work force. A strong suit in U.S. competitiveness, this is one of NSF's greatest contributions to the nation's innovation system. NSF will support three new initiatives to strengthen STEM education throughout the nation, and continue support for highly effective efforts to develop the nation's talent and workforce.

Teacher Learning for the Future (TLF), funded at $20 million, is a new teacher-training research program that will fund innovative efforts that design, develop, implement and test new teacher-training programs in cooperation with the Department of Education.

Widening Implementation and Demonstration of Evidence-based Reforms (WIDER), a new $20 million program to support research on how to achieve widespread sustainable implementation of improved undergraduate instructional practices and student outcomes at major universities.

Transforming Broadening Participation through STEM (TBPS), a third new program, will expand support for activities to broaden participation of underrepresented groups through partnerships that match research centers with other institutions committed to broadening participation. The FY 2012 investment in TBPS is $20 million.

The Faculty Early Career Development program (CAREER) develops the future scientific and technical workforce through support of young faculty who are dedicated to integrating the excitement of

research with inspired teaching and enthusiastic learning. In FY 2012, NSF will invest $222 million to support approximately 606 CAREER awards, an increase of 60 awards.

The Graduate Research Fellowship program (GRF), funded at $198 million in FY 2012, supports the development of graduate students in order to cultivate the next generation of STEM workers. In FY 2012, NSF will award 2,000 new fellowships, sustaining the doubling of new fellowship awards achieved in FY 2010. In addition, the cost of education allowance will be increased from $10,500 to $12,000, the first increase in this level since 1998. The Budget Request also includes initial funding for a stipend increase to $32,000 that will be fully implemented in FY 2013.

Community college funding continues to be a priority for NSF in FY 2012. NSF engages community colleges through several programs, including Advanced Technological Education (ATE), Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES), the Louis Stokes Alliances for Minority Participation (LSAMP), and the Tribal Colleges and Universities Program (TCUP). The total investment in community college programs is $100 million.

Promote Competitive Markets that Spur Productive Entrepreneurship.

Advances in technology, economic growth, and a prosperous society depend on the translation of fundamental discoveries into new processes, practices, and commercial products that are widely used. Many NSF activities provide incentives for scientists, engineers, and educators to undertake use-inspired research that transforms basic discoveries into applications for the benefit of society and the economy.

The Advanced Manufacturing initiative will pursue advances in sensor and model-based smart manufacturing; cyber-physical systems such as advanced robotics; smart buildings and bridges; and nano-manufacturing. This initiative holds tremendous potential for significant short-term and long-term economic impact by developing the foundation for entirely new classes and families of products that were previously unattainable. The NSF request for FY 2012 includes $190 million for these activities.

The Wireless Innovation (WIN) Fund, a component of the Administration's new Wireless Innovation and Infrastructure Initiative (WI3), will provide $1 billion to NSF over the next five years. WI3 proposes to reallocate a total of 500 megahertz of federal agency and commercial spectrum bands over the next ten years to increase the Nation's access to wireless broadband. NSF will support research on experimental wireless technology testbeds, more flexible and efficient use of the radio spectrum, and cyber-physical systems such as wireless sensor networks for smart buildings, roads, and bridges. A portion of the receipts generated through electromagnetic spectrum auctions will provide funding for WIN. NSF's FY 2012 investments will be coordinated with a number of other agencies, including the Defense Advanced Research Projects Agency and the National Institute of Standards and Technology.

Enhancing Access to the Radio Spectrum (EARS), in addition to the related research funded through the WIN, will support research into new and innovative ways to use the radio spectrum more efficiently so that more applications and services used by individuals and businesses can occupy the limited amount of available spectrum. NSF proposes an investment of $15 million in FY 2012.

Engineering Research Centers (ERCs) and **Industry/University Cooperative Research Centers (I/UCRC)** direct much of their basic research to problems with potential economic impact. By working closely with industry, these programs create enabling technologies for national needs, such as managing the electrical power system, improving manufacturing and biological processing, and supporting new healthcare information and telecommunications technologies. They also prepare students for innovation leadership in a globally competitive marketplace. The FY 2012 NSF investment is $96 million.

The Small Business Innovation Research (SBIR) and **Small Business Technology Transfer (STTR)** programs, funded at $147 million in FY 2012, build partnerships between the academic and industry sectors. They bolster the innovation economy by funding translational research at U.S. small businesses on topics that span the breadth of NSF scientific and engineering research and reflect national and societal priorities.

Catalyze Breakthroughs for National Priorities.
In FY 2012, NSF will focus on key national priority areas, where the expertise of physical, biological, and social scientists and engineers can help advance U.S. goals through frontier research. NSF-catalyzed research includes investments in clean energy and the advancing fields of bio- and nanotechnology, areas that are poised for innovative breakthroughs.

Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21) is a new portfolio that builds on NSF's long history of providing leadership for cyberinfrastructure and computational science for the U.S. academic science and engineering community. The $117 million CIF21 will advance data-enabled science through the development of novel approaches to collect, manage, and curate the vast quantities of data generated by modern observational and computational tools. The program will also expand access to cyberinfrastructure to promote collaboration, and support improved community research networks to connect people, facilities, computers, and other tools.

The Science, Engineering, and Education for Sustainability (SEES) portfolio, funded at $998 million in FY 2012, draws together NSF programs that spark innovations for tomorrow's clean energy solutions. SEES will promote a cross-disciplinary approach to sustainability science to explore the environment-energy-economy nexus in order to inform energy and environmental policies and improve our capabilities for rapid response to extreme events, such as power grid disruption, floods, or extreme weather.

Clean Energy investments, a significant component of SEES, will lead to future clean energy and energy efficiency technologies. Investments totaling $576 million are found throughout the NSF portfolio, in core research programs and in activities such as BioMaPS and SEES.

The National Nanotechnology Signature Initiatives are promising research themes that have the potential to generate applications with widespread economic benefit, as well as address national and homeland security challenges. In FY 2012, NSF will invest $117 million in three research areas: Nanotechnology for Solar Energy Collection and Conversion, Sustainable Nanomanufacturing—Creating the Industries of the Future, and Nanoelectronics for 2020 and Beyond. NSF also supports advanced manufacturing research through these investments.

The National Robotics Initiative (NRI), a new interagency initiative for FY 2012, partners NSF with the National Aeronautics and Space Administration, National Institutes of Health, and the U.S. Department of Agriculture. NRI will marshal broad science and engineering support to provide U.S. leadership in the development of next generation robotics. The focus is on robots that work beside, or cooperatively, with people in areas such as manufacturing, space and undersea exploration, healthcare and rehabilitation, military and homeland surveillance and security, education and training, and safe driving. Collaboration and coordination strengthens the research effort and also ensures that agency programs do not overlap. NSF will invest $30 million in NRI in FY 2012.

Interagency Initiatives

NSF participates in a number of interagency programs that aim to coordinate research and development activities in areas of critical national importance.

National Nanotechnology Initiative (NNI), involving 25 departments and agencies across the federal government, focuses on realizing the tremendous potential of nanotechnology. Investments in nanotechnology have led to the discovery and development of entirely new classes of materials. NSF will increase support for NNI research by 10.6 percent to a total of $456 million. This investment includes the National Nanotechnology Signature Initiatives.

The Networking and Information Technology Research and Development (NITRD) explores new frontiers in computer, information, and networking science, and coordinates these efforts among multiple agencies. NSF will increase its investment in these activities by 15.3 percent to $1.258 billion in FY 2012. The focus of NSF support includes human-computer interaction and information management, high-end computing infrastructure and applications, large scale networking, and cybersecurity and information assurance. Other initiatives in the NSF budget will explore new techniques in education and workforce training to exploit cutting edge networking and information technologies.

Homeland Security Activities across NSF will increase by 9.2 percent to about $426 million. The focus is on two general areas: protecting critical infrastructure and key assets and defending against catastrophic threats. Approximately 73 percent of this investment supports research in cybersecurity, emergency planning and response, and risk management, modeling, and simulation of resilient infrastructure.

Major Research Equipment and Facilities Construction

People and their ideas form the core of a robust science and engineering enterprise. But leading-edge tools are also needed in many cases to advance the frontiers and train students for the workplace. NSF provides the assets that will be central to success in the emerging "New Era of Observation," without precedent in terms of the sheer scale, scope, reach, resolution and volume of what we are able to observe. This new era has been enabled by the "Era of Data and Information" where we are now entering an emerging paradigm of data-enabled science.

NSF provides sophisticated tools to a broad population of scientists, engineers, students, and educators. All of the projects in the Major Research Equipment and Facilities Construction account undergo major cost and schedule reviews, as required by NSF guidelines. The following projects receive continued support.

- The **Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO)** is 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. The FY 2012 investment is $21 million.

- The **Advanced Technology Solar Telescope (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 can affect communications and navigational satellites in space and power grids here on earth, and may influence climate. The FY 2012 investment is $10 million.

- The **Atacama Large Millimeter Array (ALMA)** is the world's most sensitive, highest resolution, millimeter wavelength telescope. ALMA will provide a testing ground for theories of planet formation, star birth and stellar evolution, galaxy formation and evolution, and the evolution of the universe itself. The FY 2012 investment is $3 million.

- The **National Ecological Observatory Network (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. The FY 2012 investment is $88 million.

- The **Ocean Observatories Initiatives (OOI)** will provide continuous, interactive access to the ocean through a network of sensors designed to collect physical, chemical, geological, and biological data. OOI will produce never-before-seen views of the ocean's depths. The FY 2012 investment is $103 million.

Terminations/Reductions

NSF continually assesses its portfolio to ensure that investments align with agency priorities and focus on the frontiers of innovative science and engineering research. NSF proposes six programs for termination or reduction in FY 2012.

- **Deep Underground Science and Engineering Laboratory (DUSEL):** NSF eliminates funding for DUSEL. Termination is based on National Science Board reviews that concluded the cost and scope of DUSEL were inconsistent with the agency's traditional strengths and its role in advancing research and education across many fields and disciplines. NSF will continue to solicit proposals for future particle physics research. No funding is required in FY 2012 for DUSEL.

- **Graduate STEM Fellows in K-12 Education:** NSF eliminates the agency-wide Graduate STEM Fellows in K-12 Education (GK-12) program. While the program has been effective in meeting its overall goals, recent evaluation findings indicate that the effects of this program's fellowship experience in improving research skills is mixed, and program design limits the ability of participants to gain in-depth experience in K-12 teaching. NSF plans to build on experiences gained during the ten years of GK-12 funding to widen the breadth of graduate traineeship experiences through other programs.

- **National STEM Distributed Learning Program (NSDL):** NSF eliminates funding for the NSDL program (formerly the National STEM Digital Library). While NSDL has been successful in meeting its original goals, an October 2010 preliminary evaluation by the RAND Corporation, Steps Toward a Formative Evaluation of NSDL: Phase 2, noted the challenges of sustaining the collection in the face of changing technology, and raised concerns about the currency of the collections, peer review of collections, collaboration across pathways, and lack of standardization. NSF plans to build from the substantial NSDL experience to address key areas in cyberlearning through other programs and activities, such as Cyberlearning Transforming Education (CTE). No funding is required in FY 2012 for NSDL.

- **Research Initiation Grants to Broaden Participation in Biology:** NSF eliminates funding for the Research Initiation Grants to Broaden Participation in Biology program (RIG) because it did not achieve the goal of broadening participation in biology. The number of proposals from underrepresented groups did not increase. RIG concludes in FY 2011.

- **Science of Learning Centers (SLC):** NSF proposes to reduce funding for the SLC program, which currently supports six large-scale, long-term centers that conduct science of learning research. The on-going center review process and reviews from an external May 2010 Advisory Committee both recommended that NSF phase the program down as funding for individual centers concludes and shift resources wherever possible to enhance support for the

science of learning using non-center mechanisms. NSF expects there may be additional reductions to this program in future years as funding for individual centers comes to a close.

- **Synchrotron Radiation Center (SRC):** NSF eliminates funding for the Synchrotron Radiation Center facility at the University of Wisconsin. The SRC is 30 years old, and more powerful and capable facilities have come on-line since 1980.

Model Organization

The National Science Foundation aims to perform as a model organization in carrying forward its mission. Only 6 percent of the NSF annual budget is spent on management and administration. The FY 2012 request includes $494 million, an increase of $64 million, for activities to strengthen NSF's ability to manage its operations effectively and efficiently. These funds will support:

- Staff will include 40 additional full-time equivalents for a total of 1,365 FTE;
- IT investments of $86 million will include NSF financial system modernization (iTRAK), Research.gov expansion, and improvements to the operational IT system's reliability and security;
- Headquarters lease expiration funding is $45 million to plan and prepare for a new headquarters lease; and
- Acquisition, part of the government-wide effort to strengthen the acquisition workforce and improve capabilities in the pre-solicitation phase of major acquisitions, receives $2 million.

NSF is committed to promoting strong, independent evaluation to inform its policy decisions, program management, and performance, and to sharing publicly available findings online.

OneNSF

The concept "OneNSF" characterizes NSF efforts to perform as a model agency. The National Science Foundation will work seamlessly across organizational and disciplinary boundaries to create new knowledge, stimulate discovery and address complex societal problems and promote national prosperity.

Within this overarching context, the process of setting NSF priorities involves many considerations and results in our best view of how to advance the nation's science, engineering, and education enterprise. Internally, NSF holds a series of retreats and planning meetings where directions are developed based on an understanding of new research frontiers, emerging fields, and opportunities to advance research and educational goals. NSF also considers opportunities to coordinate and collaborate with other agencies. Staff from all Directorates and Offices participate in these activities.

The NSF system of competitive merit review helps to bring the best ideas forward from every corner of the nation. NSF continues to accept and review unsolicited proposals, a practice that ensures that unanticipated and novel ideas of great promise are heard.

Conclusion

President Obama has spoken of this generation's new "Sputnik moment," a reference to the challenge of meeting the nation's economic and societal needs in the current climate of global competition for new ideas and talent. NSF's strategic investment in research and education will help the nation meet the challenges of our times and move beyond them.

Mr. Chairman and members of the Subcommittee, I hope my testimony explains NSF's transformative role in building our nation's future prosperity and continued leadership at the frontiers of discovery, innovation and learning. Robust NSF investments in fundamental science and engineering have paid enormous dividends, improving the lives and livelihoods of generations of Americans. The FY 2012 NSF Budget Request supports leading edge programs and activities that will continue this success in the future.

This concludes my testimony. I thank you for your leadership, and will be pleased to answer any questions you may have.