AN OVERVIEW OF THE NATIONAL SCIENCE FOUNDATION BUDGET FOR FISCAL YEAR 2013

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

SECOND SESSION

TUESDAY, FEBRUARY 28, 2012

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AN OVERVIEW OF THE NATIONAL SCIENCE FOUNDATION BUDGET FOR FISCAL YEAR 2013

TUESDAY, FEBRUARY 28, 2012

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Mo Brooks [Chairman of the Subcommittee] presiding.

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Subcommittee on Research & Science Education Hearing

An Overview of the National Science Foundation Budget for Fiscal Year 2013

Tuesday, February 28, 2012
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

The Honorable Subra Suresh, Director, National Science Foundation

The Honorable Ray Bowen, Chairman, National Science Board

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

HEARING CHARTER

An Overview of the National Science Foundation Budget for Fiscal Year 2013

Tuesday, February 28, 2012
10:00 a.m. - 12:00 p.m.
2318 Rayburn House Office Building

1. Purpose

On Tuesday, February 28, 2012, the Committee on Science, Space, and Technology Subcommittee on Research and Science Education will hold a hearing to examine the Administration's proposed fiscal year 2013 (FY13) budget request for the National Science Foundation.

2. Witnesses

The Honorable Subra Suresh, Director, National Science Foundation

The Honorable Ray Bowen, Chairman, National Science Board

3. Hearing Overview

The National Science Foundation (NSF) is an independent federal agency created by Congress in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..." With a current annual budget of $7 billion, it is the funding source for over 20 percent of all federally supported basic research conducted by America's colleges and universities. NSF has been consistently recognized for its ties to the economic competitiveness and national security of the United States.

NSF Overview

NSF is the primary source of federal funding for non-medical basic research, providing approximately 40 percent of all federal support, and serves as a catalyst for science, technology, engineering, and mathematics (STEM) education improvement at all levels of education. NSF is the major source of federal funding for many fields like mathematics, computer science, and the social sciences. It supports the fundamental investigations that ultimately serve as the foundation for progress in nationally significant areas such as national security, technology-driven economic growth, energy independence, health care, nanotechnology, and networking and information technology.

Through over 11,000 new awards per year, NSF supports an average of 285,000 scientists, engineers, educators and students at universities, laboratories and field sites all over the U.S. and throughout the world. These grants fund specific research proposals that have been judged the

most promising by a rigorous and objective merit-review system. In the past few decades, NSF-funded researchers have won more than 180 Nobel Prizes.

National Science Foundation (NSF) Spending

(dollars in millions)

Account	FY11 Actual	FY12 Estimate	FY13 Request	FY13 Request versus FY12 Estimate $	FY13 Request versus FY12 Estimate %
Research and Related Activities (RRA)	**5608.4**	**5689.0**	**5983.3**	**294.3**	**5.2**
Biological Sciences (BIO)	*712.3*	*712.4*	*733.9*	*21.5*	*3.0*
Computer and Info. Science and Engineering (CISE)	*636.1*	*653.6*	*709.7*	*56.1*	*8.6*
Engineering (ENG)	*763.3*	*826.2*	*876.3*	*50.2*	*6.1*
Geosciences (GEO)	*885.3*	*885.3*	*906.4*	*21.2*	*2.4*
Mathematical and Physical Sciences (MSP)	*1312.4*	*1308.9*	*1345.2*	*36.2*	*2.8*
Social, Behavioral, and Economic Sciences (SBE)	*247.3*	*254.3*	*259.6*	*5.3*	*2.1*
Cyberinfrastructure (OCI)	*300.8*	*211.6*	*218.3*	*6.6*	*3.1*
International Science and Engineering (OISE)	*49.0*	*49.9*	*51.3*	*1.4*	*2.9*
Polar Programs (OPP)	*440.7*	*435.9*	*449.7*	*13.9*	*3.2*
Integrative Activities (IA)	*259.6*	*349.6*	*431.5*	*81.9*	*23.4*
U.S. Arctic Research Commission	*1.6*	*1.5*	*1.4*	*(0.1)*	*-4.1*
Education and Human Resources (EHR)	**861.0**	**829.0**	**875.6**	**46.6**	**5.6**
Major Research Equipment & Facilities Const (MREFC)	**125.4**	**197.1**	**196.2**	**(0.9)**	**-0.4**
Agency Operations & Award Management	**299.3**	**299.4**	**299.4**	**0**	**0**
National Science Board (NSB)	**4.5**	**4.4**	**4.4**	**0**	**0**
Office of Inspector General (OIG)	**14.0**	**14.2**	**14.2**	**0**	**0**
Totals:	**6912.6**	**7033.1**	**7373.1**	**340**	**4.8**

NSF Budget Summary

The FY13 budget request for NSF is $7.4 billion, an increase of nearly 5 percent, or $340 million over the FY12 estimated level. The request continues to keep NSF on a doubling path for funding as set out in the America COMPETES Act and America COMPETES Reauthorization Act. The budget for NSF is divided into three main accounts: Research and Related Activities, Education and Human Resources, and Major Research Equipment and Facilities Construction. The NSF FY13 budget request also includes funding requests for Agency Operations and Award Management, the National Science Board, and the Office of Inspector General.

NSF Budget Priorities

Beginning in FY13, NSF plans to enable seamless operations across organizational and disciplinary boundaries through a new OneNSF Framework. The OneNSF Framework encompasses a set of investments to "create new knowledge, stimulate discovery, address complex societal problems, and promote national prosperity."[1] OneNSF Framework priorities

[1] *FY13 NSF Budget Request to Congress*, p. 3.

for FY13 include: $257 million for Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS) to transform static systems and processes into adaptive "smart" systems; $106 million for Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21) to address the science-driven integration of cyberinfrastructure; $49 million for a new Expeditions in Education (E^2) to establish a partnership with the research directorates and the Education and Human Resources directorate (EHR) to integrate and expand STEM education research; $19 million for NSF Innovation Corps (I-Corps) to assess opportunities to transition emerging technologies into new products; $63 million for Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) to integrate existing interdisciplinary investments with new Foundation-wide activities; and $110 million for Secure and Trustworthy Cyberspace (SaTC) to align Foundation investments with the national cybersecurity strategy. (See Appendix A for more details on each program.)

OneNSF Framework priorities also incorporate the existing Science, Engineering and Education for Sustainability (SEES) program, which crosses all NSF directorates and has a goal of advancing "climate and energy science, engineering, and education to inform the societal actions needed for environment and economic sustainability and sustainable human well-being." The FY13 budget request for SEES is $202.5 million, an increase of $45.5 million or 29 percent. When compared to the FY12 budget request of $998.19 million, the SEES portfolio request appears to have shrunk dramatically. The FY12 request estimated spending on SEES for FY11 to be $660.74 million; the FY13 request reflects FY11 actual spending to be $87.96 million or $572.78 million less than reported in the previous year. According to NSF, the SEES program was rebaselined in FY12 to reflect more stringent criteria for investments, including strong requirements for interdisciplinarity and systems based research, including social and economic aspects. All SEES programs established after FY10 are included in the rebaselined SEES, while legacy programs are excluded.

The overall budget request for OneNSF Framework activities is $807 million, an increase of $291 million or 56 percent over the FY12 level.

Research and Related Activities (RRA)

The FY13 budget request includes over $5.9 billion for Research and Related Activities (RRA), an increase of $294 million or 5.2 percent over FY12. RRA is made up primarily of six disciplinary directorates: non-biomedical life sciences (BIO); computer sciences (CISE); engineering (ENG); geosciences (GEO); math and physical sciences (MPS); and social, behavioral, and economic sciences (SBE). The FY13 budget request provides an increase for each of these disciplinary directorates ranging from 2 percent for SBE to nearly 9 percent for CISE. The request for the Office of Integrative Activities (IA) is $431 million, a 23 percent increase from FY12 primarily due to the fact that it will serve as the organizational lead for INSPIRE.

In addition to the significant increases in funding for the OneNSF Framework priorities, the FY13 NSF RRA budget request also illustrates the manner in which NSF plans to use funds to highlight several Administration priorities, including: "a focus on interdisciplinary science and engineering; innovative research on clean energy and sustainability; key investments in advanced manufacturing, break-through materials, wireless communications, and smart systems; and emphasis on bolstering our Nation's cybersecurity; strong support for new faculty and young

investigators; and vital evidence-based educational activities.[2]" NSF will continue investments in a number of multifaceted programs, including a $335 million investment in Clean Energy; a $149 investment in Advanced Manufacturing; a $216 million investment in the Faculty Early Career Development program (CAREER); a $243 million total investment in the Graduate Research Fellowship program (GRF) ($121 million from RRA); and a $158 million investment in the Experimental Program to Stimulate Competitive Research (EPSCoR).

Education and Human Resources (EHR)

The FY13 budget request for Education and Human Resources (EHR) is $845.6 million, a $46.6 million or 5.6 percent increase over the FY12 level and the largest percentage increase for the agency.

Significant increases in the FY13 budget request include $20 million, a $12 million or 150 percent increase over FY12, for the Widening Implementation and Demonstration of Evidence-based Reforms (WIDER)/E^2 program and $20.5 million for a new Expeditions in Education (E^2) initiative to engage, empower, and energize learners in STEM.

The FY13 budget request continues to flat fund the Robert Noyce Scholarship Program (NOYCE) at $54.9 million and decreases funding for the federal Cyber Service: Scholarship for Service/Cybercorps (SFS) program by 44 percent to $25 million. Likewise, the Administration's budget request continues to place a high priority on Graduate Research Fellowships (GRF) by increasing the funding to $121.5 million, a 10.8 percent increase over the FY12 level, while significantly reducing funding for the Integrative Graduate Education and Research Traineeship Program (IGERT) to $22.9 million, a 26.7 percent cut.

Several new or reorganized initiatives are to be carried out in conjunction with the Department of Education (ED), OSTP, and other federal science mission agencies to address national priorities in STEM education through a coordinated STEM education investment strategy. The budget request includes three specific NSF EHR collaborations with ED in FY13, including flatlining the NSF Math and Science Partnership (MSP) program at $57 million and aligning it with ED's Effective Teaching and Learning: STEM initiative (formerly ED's MSP program). In addition, the request includes $15 million from the Discovery Research K-12 (DR K-12) and $15 million from the TUES program to be directed towards a new evidence-based grant competition focused on developing, evaluating, and scaling proven practices that can help increase student learning in mathematics K-16. And lastly, efforts to establish joint standards of evidence for STEM education innovations and research are underway between EHR and ED's Institute of Education Sciences (IES), to improve the evidence base for STEM education programs across government.

Additionally, the FY13 request includes the renaming of the Informal Science Education program, now referred to as the Advancing Informal STEM Learning program (AISL). The new name emphasizes planned changes to the program to fund projects that advance the field, highlight learning outside of school, are related to all fields of STEM education, and focus on learning by individuals of all ages. The FY13 request for AISL is $47.8 million, a decrease of $13.9 million or 22.1 percent from FY12. According to the FY13 request, "AISL will support fewer awards, focusing on the research and model building of the program to better understand

[2] *FY13 NSF Budget Request to Congress*, R&RA p. 1.

effective means and innovative models for engaging today's young people and adults in science outside of school settings.[3]"

The FY13 request also reflects a fundamental reframing of the EHR investment portfolio. EHR retains its existing four divisions: 1) Research on Learning in Formal and Informal Settings (DRL); 2) Undergraduate Education (DUE); 3) Human Resource Development (HRD); and 4) Graduate Education (DGE). Funding for each division will now fall under one of three categories: Core R&D, Leadership, and Expeditions. The Core R&D areas of research include STEM learning, STEM learning environments, broadening participation and institutional capacity in STEM, and STEM professional workforce preparation. A new $5 million "Core Launch Fund" to allow a first round of grant awards will shape each area and will be administered by one of the divisions. The Leadership investments will focus on the next generation of STEM researchers and educators. And finally, the Expedition investments will be a key component for EHR to partner with other NSF directorates and offices and with ED to take on specific challenges over defined, shorter periods of time.

Major Research Equipment and Facilities Construction (MREFC)

The MREFC account funds the construction of large research facilities, such as telescopes and research ships. Funding for the design, operation and management of these major user facilities is included in the RRA budget.

The FY13 budget request includes $196.2 for the Major Research Equipment and Facilities Construction (MREFC) account. This is a slight 0.4 percent decrease from FY12. The request includes funding for four existing projects: 1) $91 million for the National Ecological Observatory Network (NEON); 2) $25 million for the Advanced Technology Solar Telescope (ATST); 3) $15 million for the Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO); and $65 million for the Ocean Observatories Initiatives (OOI). The IceCube Neutrino Observatory (IceCube) and the Atacama Large Millimeter Array (ALMA) no longer require MREFC funding.

Agency Operations and Award Management (AOAM)

The AOAM account funds the internal operations of NSF. The FY13 budget request includes $299.4 million for AOAM, this is a flat funding request from FY11 and FY12. The NSF building lease is scheduled to expire in April, 2013; the FY 13 budget request for AOAM includes potential increased GSA rental costs should an interim occupancy agreement be necessary.

National Science Board (NSB)

The NSB is responsible for establishing policies for NSF and for providing national science policy advice to the President and Congress. The FY13 budget request would provide level funding for NSB at $4.4 million. "The FY13 Budget Request will enable the Board to fulfill its policy-making responsibilities for NSF.[4]"

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[3] *FY13 NSF Budget Request to Congress*, EHR p. 8
[4] *FY13 NSF Budget Request to Congress*, NSB p. 1.

Office of the Inspector General (OIG)

The OIG conducts and supervises audits and investigations of NSF programs, evaluates allegations of research misconduct, and issues semiannual reports to NSB and Congress regarding problems, corrective actions, and progress towards improving the management and conduct of NSF programs. The FY13 budget is $14.2 million for OIG, this mirrors the estimated funding level for FY12. "The FY13 Request level identifies the resources needed to support OIG, including amounts for personnel compensation and benefits, contract services, training, travel, supplies, materials, and equipment.[5]"

Interagency Research Activities

NSF Spending on Interagency Research Activities
(dollars in millions)

Interagency Program	FY11 Actual	FY12 Estimate	FY13 Request	FY13 Request versus FY12 Estimate $	FY13 Request versus FY12 Estimate %
National Nanotechnology Initiative (NNI)	485	426	435	9	2.1
Networking and Information Technology R&D (NITRD)	1189	1138	1207	69	6.1
US Global Change Research Program (USGCRP)	321	333	333	0	0

National Nanotechnology Initiative (NNI)

The National Nanotechnology Initiative (NNI) focuses on R&D that creates materials, devices, and systems that exploit the fundamentally distinct properties of matter as it is manipulated at the nanoscale. There are currently 25 federal agencies that participate in NNI, with 15 of those agencies reporting a nanotechnology R&D budget. The FY13 budget request for NNI is $1.8 billion; NSF's contribution in this request would be $435 million, an increase of 2.1 percent from FY12. The Administration's budget request continues funding for three signature initiatives: Nanoelectronics for 2020 and Beyond; Sustainable Manufacturing: Creating the Industries of the Future; and Nanotechnology for Solar Energy Collection and Conversion.

Networking and Information Technology R&D (NITRD)

The mission of the NITRD program is to accelerate progress in the advancement of computing and networking technologies and to support leading edge computational research in a range of science and engineering fields, including high-end computing systems and software, networking, software design, human-computer interaction, health IT, and cybersecurity and information assurance research activities. Information technology research continues to play a critical role in U.S. economic strength. Currently, 14 federal agencies contribute funding to the NITRD program and additional agencies participate in planning activities.

The FY13 NITRD budget request is $3.8 billion; NSF's contribution in this request would be $1.2 billion, an increase of 6.1 percent from FY12. The Administration request includes a focus

[5] *FY13 NSF Budget Request to Congress*, OIG p. 1.

on research to improve our ability to derive value and scientific inferences from enormous quantities of data, and continues to emphasize foundations for assured computing and secure hardware, software, and network design and engineering to address the goal of making Internet communications more secure and reliable.

On February 7, 2011, the Committee on Science, Space, and Technology ordered to be reported H.R. 3834, *Advancing America's Networking and Information Technology Research and Development Act of 2012*. This measure updates and further codifies the NITRD program and is similar to H.R. 2020 from the 111th Congress that passed the House twice, but was not enacted.

U.S. Global Change Research Program (USGCRP)

The FY13 budget request is $2.6 billion for the interagency USGCRP; NSF's contribution in this request would be $333 million, a level funding request from FY12. Started in 1989, the USGCRP is an interagency effort comprised of 13 departments and agencies. Activities of the USGCRP are grouped under the following areas: improving knowledge of Earth's past and present climate variability and change; improving understanding of natural and human forces of climate change; improving capability to model and predict future conditions and impacts; assessing the Nation's vulnerability to current and anticipated impacts of climate change; and improving the Nation's ability to respond to climate change by providing climate information and decision support tools that are useful to policymakers and the general public.

APPENDIX A: OneNSF Framework Priorities[6]

- **Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS)** ($257.42 million) will transform static systems, processes, and edifices into adaptive, pervasive "smart" systems with embedded computational intelligence that can sense, adapt, and react. The smart systems of tomorrow, created through CEMMSS, will vastly exceed those of today in terms of adaptability, autonomy, functionality, efficiency, reliability, safety, and usability. CEMMSS plays a key role in NSF's growing portfolio of advanced manufacturing investments.

- **Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21)** ($106.08 million) aims in FY 2013 to more deeply address a highly science-driven integration of cyberinfrastructure (CI), supporting development of new statistical, mathematical, and computational methods, algorithms, and tools, as well as the cultivation of the next generation of computational and data-enabled researchers who prototype, develop, and use CI in all disciplines.

- **Expeditions in Education (E2)** ($49.0 million) establishes a partnership between the Directorate for Education and Human Resources (EHR) and other research directorates and offices. E2 will integrate, leverage, and expand STEM education research and development to improve learning in science and engineering disciplines and capitalize on the scientific assets across NSF to enhance EHR investments in learning and education.

- **NSF Innovation Corps (I-Corps)** ($18.85 million), launched in FY 2011, will continue to establish opportunities to assess the readiness of emerging technology concepts for transitioning into valuable new products through public-private partnerships. I-Corps will bring together technological, entrepreneurial, and business know-how to move discoveries toward commercialization.

- **Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE)** ($63.0 million) integrates NSF's existing interdisciplinary efforts with a suite of new Foundationwide activities. INSPIRE encourages research that involves multiple disciplines, connects disciplines, or creates new disciplines. It aims to widen the pool of prospective discoveries that may be overlooked by traditional mechanisms.

- **The Secure and Trustworthy Cyberspace (SaTC)** ($110.25 million) investment aligns NSF's cybersecurity investments with the four thrusts outlined in the December 2011 national cybersecurity strategy, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program*. SaTC directly addresses the critical Administration priority of cybersecurity issues by supporting research that seeks to protect the Nation's critical information technology infrastructure, including the Internet, from a wide range of threats that challenge its security, reliability, availability, and overall trustworthiness.

- **Science, Engineering, and Education for Sustainability (SEES)** ($202.50 million) focuses on targeted programs that promote innovative interdisciplinary research to address pressing societal issues of clean energy and sustainability. In FY 2013, SEES includes five programs that are consistent with the SEES long-term vision: Coastal SEES; Arctic SEES; Sustainable Chemistry, Engineering, and Materials (SusChEM); Creating a More Disaster-Resilient America (CaMRA); and a program on the Role of Information Sciences and Engineering in SEES (RISES).

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[6] *FY13 NSF Budget Request to Congress*, Overview p. 3-4.

Chairman BROOKS. The Subcommittee on Research and Science Education will come to order. Good morning. Welcome to today's hearing entitled, "An Overview of the National Science Foundation Budget for Fiscal Year 2013." The purpose of today's hearing is to examine the Administration's proposed fiscal year 2013 budget request for the National Science Foundation.

I now recognize myself for five minutes for an opening statement.

I am pleased to welcome Dr. Suresh and Dr. Bowen to discuss NSF's priorities for fiscal year 2013.

Before I hear from them I would like to make a few comments concerning the President's proposed fiscal year 2013 budget. From where I sit the President's fiscal year 2013 budget is an irresponsible, pie-in-the-sky wish list that fails to take into account America's deteriorating financial condition and seeks to pay for programs with money America simply does not have.

Let me explain. America faces what may be its greatest financial threat in its history. In fiscal year 2011, America's revenues were $2.3 trillion, and our spending was $3.6 trillion, yielding a $1.3 trillion deficit. Stated differently, 36 cents of every dollar spent by American in fiscal year 2011 was borrowed money. Under the President's guidance America has for the first time ever run three consecutive trillion dollar plus deficits. Last November America's accumulated debt blew through the $15 trillion mark. Some time this year America's accumulated debt will blow through the $16 trillion mark.

Now, if you are like most folks, it is hard to grasp numbers that are in the trillions. Let me simplify the trillions for a moment. Imagine a family that has not been paying attention to its finances and has started to feel insecure about where they are. The mom and dad sit at the dinner table and go over their finances for the past three years. They tally up their average income and discover they have been earning $50,000 per year for each of those three years. They feel pretty good about that. Then they get to the expense side of the ledger. They add up their bills and expenses and discover that they have averaged spending $80,000 per year for three years. Stated differently, they have been losing $30,000 per year for each of those three years.

This $30,000 per year annual deficit would cause most families to shutter. They would worry about whether their house will be foreclosed or their cars repossessed. They would worry about whether they can avoid bankruptcy. As that husband and wife struggle with where to cut spending or whether one of them can get another job or work overtime, the wife picks up the Visa bill. She opens it. It is a bill for $320,000. Now, imagine how overwhelmed that couple must feel, how hopeless the situation may seem.

Well, those numbers, $50,000 per year in income, $80,000 a year in expenses, and $320,000 in accumulated debt mirror the ratios of America's $2.3 trillion income, $3.6 trillion in expenses, and $15 trillion in debt.

All America is is one very large family of 311 million citizens. The only substantive difference between the hypothetical family I just gave you and America is one of size. Yet the impact of an American insolvency and bankruptcy will have much greater cata-

strophic effects on all American citizens, which brings me to the President's proposed fiscal year 2013 budget.

It does absolutely nothing to alleviate that threat or minimize the risk of an American insolvency or bankruptcy. Rather than cutting spending, the President proposes to increase spending by over $200 billion to $3.8 trillion or nearly a quarter of our gross domestic product, roughly 23.3 percent. Under this President's budget America's gross national debt will increase from $15 trillion today to $26 trillion ten years from now and this accumulated debt includes taking into account the President's proposal for the largest tax increase in U.S. history.

The President's fiscal year 2013 budget is simply not sustainable. It is not responsible. It is more of the same. It places America's future at risk. All of which brings us to today's hearing.

America must figure out a way to better prioritize and leverage our precious and limited federal dollars. Today we will be examining the President's fiscal year 2013, budget request for the National Science Foundation, which totals $7.4 billion, an increase of $340 million or 4.8 percent over the fiscal year 2012, estimate.

While my colleagues and I disagree—excuse me, may disagree on the best priorities for federal research dollars, I am sure that we can all agree that support for basic research is important and essential to our economy. Basic research is an investment in America's future. It is a productive job creator. The fruits of that research create jobs and opportunities that oftentimes change our lives, but even this important endeavor must be undertaken in a fiscally-responsible way in our current economic climate.

Through what many consider the gold standard of merit review processes, the NSF has played a vital role in funding basic research crucial to the economic security and international competitiveness of the United States for over 60 years now. As most in this room know, the National Science Foundation is the primary source of Federal Government support for non-health-related research and development at America's colleges and universities.

The Administration's budget request for NSF focuses on fostering the development of a clean energy economy, supporting future job creation through advanced manufacturing and emerging technologies, protecting critical infrastructure, promoting multidisciplinary research in new materials, wireless communications, cyber infrastructure and robotics, developing the next generation of scientific leaders through support for graduate fellowships and early career faculty, and advancing evidence-based reforms in science and mathematics education.

While a nearly five percent increase for NSF in fiscal year 2013 shows stronger fiscal restraint than the fiscal year 2012 request at 13 percent, I remain concerned that our federal agencies still are not doing enough to encourage austerity and properly prioritize scarcer federal funds. It is the job of every Member on this Subcommittee to ensure that all federal investments serve to strengthen the economy. It is my hope that together we can work to achieve this goal, while at the same time exhibiting fiscal accountability.

NSF has a long and proven track record, one in which we are all proud, and I have every reason to believe NSF will continue this good work with whatever budgets are forthcoming from Congress.

I look forward to hearing the testimony to be presented today and thank both of you gentlemen for taking the time out of your very busy schedules to join us.

[The prepared statement of Mr. Brooks follows:]

PREPARED STATEMENT OF CHAIRMAN MO BROOKS

Good morning and welcome. I am pleased to welcome Dr. Suresh and Dr. Bowen to discuss NSF's priorities for fiscal year 2013.

Before I hear from them, I would like to make a few comments concerning the President's proposed FY 2013 budget. From where I sit, the President's FY 2013 budget is an irresponsible pie-in-the-sky wish list that fails to take into account America's deteriorating financial condition and seeks to pay for programs with money America simply does not have.

Let me explain. America faces what may be its greatest financial threat in its history. In FY 2011, America's revenues were $2.3 trillion and our spending was $3.6 trillion, yielding a $1.3 trillion deficit. Stated differently, 36 cents of every dollar spent by America in FY 2011 was borrowed money. Under the President's guidance, America has, for the first time ever, run three consecutive trillion dollar plus deficits. Last November, America's accumulated debt blew through the $15 trillion mark. Sometime this year, America's accumulated debt will blow through the $16 trillion mark.

Now, if you are like most folks, it is hard to grasp numbers that are in the trillions. Let me simplify the trillions for a moment. Imagine a family that has not been paying attention to its finances and is starting to feel insecure about where they are. The mom and dad sit down at the dinner table and go over their finances for the past three years. They tally up their average income and discover they have been earning $50,000 per year for three years. They feel pretty good about that. Then they get to the expense side of the ledger. They add up their bills and expenses and discover that they have averaged spending $80,000 per year for three years. Stated differently, they have been losing $30,000 per year for each of three years.

This $30,000 per year annual deficit would cause most families to shudder. They would worry about whether their house will be foreclosed on or their cars repossessed. They would worry about whether they can avoid bankruptcy. As that husband and wife struggle with where to cut spending or whether one of them can get another job or work overtime, the wife picks up the VISA bill. She opens it. It is a bill for $320,000! Now imagine how overwhelmed that couple must feel. How hopeless the situation may seem.

Well, those numbers—$50,000/year in income, $80,000 in expenses, and $320,000 in accumulated debt—mirror the ratios of America's $2.3 trillion income, $3.6 trillion in expenses and $15 trillion in debt. All America is is one very large family of 311 million citizens. The only substantive difference between the hypothetical family I just gave you and America is one of size. Yet the impact of an American insolvency and bankruptcy will have much greater catastrophic effects on all American citizens, which brings me to the President's proposed FY 2013 budget. It does absolutely nothing to alleviate that threat or minimize the risk of an American insolvency or bankruptcy. Rather than cutting spending, the President proposes to increase spending by over $200 billion, to $3.8 trillion, or nearly a quarter of our gross domestic product (23.3 percent).

Under this President's budget, America's gross national debt will increase from $15 trillion today to $26 trillion ten years from now, and this accumulated debt includes taking into account the President's proposal for the largest tax increase in U.S. history. The President's FY 2013 budget is not sustainable. It is not responsible. It is more of the same. It places America's future at grave risk. All of which brings us to today's hearing. America must figure out a way to better prioritize and leverage our precious and limited federal dollars.

Today, we will be examining the President's FY 2013 budget request for NSF, which totals $7.4 billion, an increase of $340 million, or 4.8 percent, over the FY 2012 estimate. While my colleagues and I may disagree on the best priorities for federal research dollars, I am sure that we can all agree that support for basic research is important and essential to our economy. Basic research is an investment in America's future. It is a productive, "job creator". The fruits of that research create jobs and opportunities that often-times change our lives, but even this important endeavor must be undertaken in a fiscally responsible way in our current economic environment.

Through what many consider the gold-standard of merit-review processes, the National Science Foundation has played a vital role in funding basic research crucial to the economic security and international competitiveness of the United States for over 60 years now. As most in this room know, NSF is the primary source of federal government support for non-health-related research and development at America's colleges and universities.

The Administration's budget request for NSF focuses on fostering the development of a clean energy economy; supporting future job creation through advanced manufacturing and emerging technologies; protecting critical infrastructure; promoting multidisciplinary research in new materials, wireless communications, cyber infrastructure and robotics; developing the next generation of scientific leaders through support for graduate fellowships and early career faculty; and advancing evidence-based reforms in science and mathematics education.

While a nearly five percent increase for NSF in FY13 shows stronger fiscal constraint than the FY 2012 request at 13 percent, I remain concerned that our federal agencies still are not doing enough to encourage austerity and properly prioritize scarcer federal funds. It is the job of every Member on this Subcommittee to ensure that all federal investments serve to strengthen the economy. It is my hope that together we can work to achieve this goal, while at the same time exhibiting fiscal accountability.

NSF has a long and proven track record, one in which we are all proud, and I have every reason to believe NSF will continue this good work with whatever budgets are forthcoming from Congress.

I look forward to hearing the testimony to be presented today, and thank both of you gentlemen for taking the time out of your very busy schedules to join us.

Chairman BROOKS. The Chair now recognizes Mr. Lipinski for an opening statement.

Mr. LIPINSKI. Thank you, Chairman Brooks, and I want to welcome back Dr. Suresh and Dr. Bowen.

And certainly as the Chairman said, in this challenging fiscal environment it is our job to make tough choices and set priorities. I feel strongly we need to prioritize investments that deliver real returns to taxpayers and boost our economic competitiveness. As the chairman says, this is—the NSF certainly is a place that that happens.

As a result, I am pleased that the Administration's fiscal year 2013 budget request continues to emphasize science, innovation, and STEM education generally and the National Science Foundation in particular.

But I think it is also important for me to urge everyone to be realistic about the notion of doubling the NSF's budget and focus instead on maintaining a sustainable, predictable path of growth. While I do think that doubling funding would yield enormous dividends for our country, I think that we should all recognize that aspirations that ignore the reality of our budget deficit are not particularly helpful to the agency or to the scientific community.

Predictability will help our research institutions to plan, while helping our scientists avoid the booms and busts that have driven some of our brightest minds out of the lab. In my view the President's fiscal year 2013 request for the NSF strikes a good balance.

I have a few comments on specific programs and proposed activities.

First, I am very excited to see the proposed expansion of the I–Corps Program. As I have told Dr. Suresh before, I strongly believe that this program embodies NSF's original mission of both promoting the progress of science and advancing the national prosperity. Let's not forget that second part, especially when we are looking to maximize efficiency of our federal investments.

Although it is only one quarter of one percent of NSF's budget, I think this program will yield disproportionate benefits, helping turn NSF's research investments into jobs and encouraging both scientists and universities to push their work outside the ivory tower to the immediate benefit of all Americans.

For my colleagues that haven't looked at this program in depth, it is important to note that we are talking about a stage of commercialization well before private sector financing gets involved. The goal of I–Corps is to educate scientists to help them establish the viability of an idea even before forming a new small business.

Last month I was able to meet with Steve Blank at Stanford to learn more about his implementation of this innovative, potentially game-changing program. I look forward to working with the NSF as this program is expanded and improved.

Second, I am pleased that for the first time in many years we are seeing growth in the education budget similar to that in the research budget. We will disagree over some of the particulars in the EHR request, including the 22 percent cut to the informal STEM education programs and flat funding for the NOYCE scholarships. But I think the overall increase is a well-earned vote of confidence in the current leadership of EHR.

There are many other interesting proposals in this budget request, including the increased focus on advanced manufacturing research that I called for in COMPETES, the secure and trustworthy cyberspace initiative that is another priority issue for me, and a joint effort between NSF and the Department of Education on math education. It is good to see that the request would also put all the MREFC projects back on track after a couple of years of significant cuts.

I do have some concern about the Administration's proposals to hold NSF's operating budget flat. That seems like an odd place to start when in every other year in recent memory the agency has expressed concern about how thinly its staff has been stretched after Congress has flat lined the ops budget.

In closing, I have to say that an increase in the budget request makes it easier for you to dream big and for me to offer mostly positive comments, but unfortunately, I think it is unlikely that Congress will be able to match your request when we eventually pass the budget. As I indicated at the outset, I believe that strong and sustained investments in the NSF STEM education and innovation generally are critical for our Nation's future.

My colleagues in Congress have on a bipartisan basis historically agreed with me, and I hope that will continue to be the case. I think this type of an investment is critical to the future growth of our country. We cannot allow this to fall to the wayside.

I thank both of you for, Dr. Suresh and Dr. Bowen, for your work. I look forward to your testimony and look forward to our discussion. Thank you.

[The prepared statement of Mr. Lipinski follows:]

PREPARED STATEMENT OF RANKING MEMBER DANIEL LIPINSKI

Thank you Chairman Brooks for holding this hearing and welcome back Dr. Suresh and Dr. Bowen.

In this challenging fiscal environment it is our job to make tough choices and to set priorities. I feel strongly that we need to prioritize investments that deliver real

returns to taxpayers and boost our economic competitiveness. As a result I am pleased that the Administration's FY13 budget request continues to emphasize science, innovation, and STEM education generally, and the National Science Foundation in particular.

But I think it is also important for me to urge everyone to be realistic about the notion of doubling the NSF's budget, and focus instead on maintaining a sustainable, predictable path of growth. While I do think that doubling funding would yield enormous dividends for our country, I think that we should all recognize that aspirations that ignore the reality of our budget deficit are not particularly helpful to the agency or the scientific community. Predictability will help our research institutions to plan, while helping our scientists avoid the booms and busts that have driven some of our brightest minds out of the lab. In my view the President's FY13 request for the NSF strikes a good balance. I have just a few comments on specific programs and proposed activities.

First, I am very excited to see the proposed expansion of the I-Corps program. As I've told Dr. Suresh before, I strongly believe that this program embodies the NSF's original mission of both promoting the progress of science and advancing the national prosperity. Let's not forget that second part, especially when we are looking to maximize the efficiency of our federal investments. Although it's only about one quarter of 1 percent of NSF's budget, I think this program will yield disproportionate benefits, helping turn NSF's research investments into jobs, and encouraging both scientists and universities to push their work outside of the ivory tower to the immediate benefit of all Americans.

For my colleagues who haven't looked at this program in depth, it is important to note that we are talking about a stage of commercialization well before private sector financing gets involved. The goal of I-Corps is to educate scientists to help them establish the viability of an idea even before forming a new small business. Last month I was able to meet with Steve Blank at Stanford to learn more about his implementation of this innovative, potentially game-changing program. I look forward to working with the NSF as this programs is expanded and improved.

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There are many other interesting proposals in this budget request, including the increased focus on advanced manufacturing research that I called for in COMPETES, the Secure and Trustworthy Cyberspace initiative that is another priority issue for me, and the joint effort between NSF and the Department of Education on math education. And it's good to see that the request would put all of the MREFC projects back on track after a couple of years of significant cuts.

I do have some concern about the Administration's proposal to hold NSF's operating budget flat. That seems like an odd place to start when in every other year in recent memory the agency has expressed concern about how thinly its staff has been stretched after Congress has flat-lined the ops budgets.

In closing, I have to say that the increase in your budget request makes it easier for you to dream big and for me to offer mostly positive comments. But, unfortunately, I think it's unlikely that Congress will be able to match your request when we eventually pass a budget. As I indicated at the outset, I believe that strong and sustained investments in the NSF, STEM education, and innovation generally are critical for our nation's future. My colleagues in Congress have, on a bipartisan basis, historically agreed with me, and I hope that will continue to be the case. I think this type of investment is critical to the future growth of our country.

I thank Dr. Suresh and Dr. Bowen for being here today; I look forward to your testimony and our discussion.

Chairman BROOKS. Thank you, Mr. Lipinski. If there are Members who wish to submit additional opening statements, your statement will be added to the record at this point.

At this time I would like to introduce our witnesses for today's hearing. Dr. Subra Suresh was nominated by President Obama and unanimously confirmed by the United States Senate as the Director of the National Science Foundation in September, 2010. Prior to assuming his current role, Dr. Suresh served as the Dean of the

School of Engineering and a Vannevar Bush Professor of Engineering at the Massachusetts Institute of Technology.

Dr. Ray Bowen was appointed to the National Science Board in 2002 and reappointed in 2008. He was elected Chairman in 2010. Prior to joining the NSB he served as President of Texas A&M and is currently President Emeritus and Professor Emeritus of Mechanical Engineering. Dr. Bowen is also a distinguishing visiting professor at Rice University.

As our witnesses should know, spoken testimony is limited to five minutes each, after which Members of the Committee will have five minutes each to ask questions.

I now recognize our first witness, Dr. Subra Suresh. Dr. Suresh, you are recognized for five minutes.

STATEMENT OF SUBRA SURESH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. SURESH. Thank you, Mr. Chairman. Chairman Brooks, Ranking Member Lipinski, and Members of the Subcommittee, it is my privilege to be here with you today to discuss the National Science Foundation's fiscal year 2013 budget request.

Today science and technology are the new frontiers of American prosperity. The Nation's well-being and global competitiveness depend more than ever before on the steady stream of new ideas and highly-skilled science, technology, engineering, and mathematical talent that the National Science Foundation supports and particularly the young researchers that NSF so skillfully nurtures.

NSF supports the full breadth of science and engineering research and education. We seek emerging ideas with the potential to transform the world, establish new paradigms, and foster new industries. NSF has helped to make the U.S. an undisputed world leader in science, technology, and innovation. Our universities rank among the best in the world. Our scientists and engineers have led the world in discovery and innovation. Our transformative discoveries have created a vibrant private sector and great jobs.

Worldwide frontier research and technological innovation driven by a creative and skilled science and engineering workforce are the new engines of economic growth. Science and technology are improving the prospects for economic prosperity and the rising standard of living around the globe.

It is a measure of our success that other nations are emulating the NSF model. The U.S. can both be a partner and a leader in this global enterprise.

The NSF budget request moves America forward by connecting the science and engineering enterprise with benefits for Americans in areas critical to job creation, a growing economy, and a higher standard of living.

The Administration and Congress have conveyed a clear determination to build on the Nation's history of success in leading-edge discovery and innovation. That is the unmistakable message of the President's 2013 budget request for NSF of $7.373 billion, an increase of 4.8 percent. Bipartisan Congressional support for the 2.5 percent increase in our 2012 budget reinforces that message.

NSF has identified critical funding priorities that will provide long-term benefits for the Nation. As good stewards of the public

trust, we have also made tough choices to reduce and eliminate lower priority programs, identify opportunities to leverage resources for maximum impact, and held the line on NSF's operating expenses.

This budget presents a well-targeted portfolio of innovative investments that provides increased support for fundamental research in all fields of science and engineering. This core research, which constitutes the largest share of NSF expenditures, lays the foundation for progress in science and technology and enhances our ability to address emerging challenges.

NSF investments in advanced manufacturing, clean energy technologies, cyber security, and STEM education will support the Administration's government-wide priorities in these critical areas. In 2013, NSF will support the cross agency advanced manufacturing, national robotics, and materials genome initiatives by investing in research that makes manufacturing faster, cheaper, and smarter.

Working in concert with other federal agencies NSF will advance research to ensure that the Nation's computer and networking infrastructure are secure and reliable and to support a cyber security workforce. NSF will support clean energy research as a component of an initiative to address national challenges and environmental sustainability.

The Administration's new K through 16 mathematics education initiative, combines NSF's expertise in mathematics education research with the Department of Education's ability to scale up successful programs at state and local levels. NSF's larger suite of educational investments builds on the recognition that science and engineering talent is the foundation of America's future. Areas of educational investments span early learning to college completion. NSF brings its strength in supporting fundamental research and education to each of these broad areas of collaboration.

Mr. Chairman, Members of the Subcommittee, I hope my testimony conveys the Foundation's vital role in ensuring that America remains at the epicenter in research, innovation, and learning that is driving 21st century economies. More than ever the future prosperity and wellbeing of Americans depend on sustained investments in our science and technology.

I will be pleased to answer any questions you may have. Thank you.

[The prepared statement of Dr. Suresh follows:]

PREPARED STATEMENT OF DR. SUBRA SURESH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. Subra Suresh
Director
National Science Foundation

Testimony
Before the Subcommittee on Research and Science Education
United States House of Representatives

On
The President's Fiscal Year 2013 Budget Request

February 28, 2012

Chairman Brooks, Ranking Member Lipinski, 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) 2013 Budget Request. My name is Subra Suresh, and I am the Director of the National Science Foundation.

I hope to make a clear and compelling case for the continuing vital role NSF's support for science and engineering research and education plays in innovation and economic growth, especially during these times of constrained budgets.

The President's FY 2013 Budget Request reflects wise stewardship of federal funding through innovative, targeted investments. The Request totals $7.373 billion, an increase of $340.0 million (4.8 percent) over the FY 2012 Enacted level. The FY 2013 Request provides increased support for core programs in fundamental research and education in all fields of science and engineering. This investment moves our nation forward by connecting the science and engineering enterprise with potential economic, societal, and educational benefits in areas critical to creating high-quality jobs, growing the economy, and ensuring national security. This follows bipartisan support in the FY 2012 budget for a 2.5-percent increase over the 2011 Enacted level.

NSF is the only federal agency with a mandate to support research and education in every discipline. The results of frontier research have a long record of improving lives and meeting national needs. They are the very bedrock of economic growth; the path to sustainability in energy, agricultural, and environmental domains; the seeds of the next technology revolution; and the foundation for advances in medicine. Sustained momentum in NSF's core programs is essential for progress in science and engineering. NSF's broad scope uniquely positions us to integrate the natural sciences and engineering with social, behavioral, and economic sciences to

address the complex societal challenges of today. For all these reasons, the FY 2013 Budget Request provides increased support for the core fundamental research programs across NSF.

NSF: Building a Foundation for Success

NSF has played a significant role in U.S. prosperity, and in the education and development of the nation's science and engineering workforce. For decades, NSF has supported scientists and engineers in their pursuit of world-changing discoveries and innovation that, in turn, created opportunities for private sector growth and for Americans to have good jobs.

Since 1952, the first year that NSF awarded research grants, 196 Nobel Prize recipients have received NSF funding at some point in their careers for their work in physics, chemistry, medicine, and economics. Today, their transformative work addresses society's grand challenges in the areas of energy, environment, and health, as well as national and economic security.

The United States has a long history of investment in and deployment of technological advances derived from advances in basic research facilitated by NSF. For example, research funded by NSF at the National Center for Atmospheric Research and universities was instrumental in the development of Doppler radar, which benefits most Americans regularlythrough improved weather forecasting. NSF-supported fundamental research in physics, mathematics, and high-flux magnets led to the development of today's magnetic resonance imaging (MRI), employed ubiquitously throughout medicine.

Furthermore, NSF provides a much-needed bridge between research and discovery that would otherwise be neglected and remain untapped by the commercial marketplace. In the 1970's, research on solid modeling by NSF-funded scientists at Carnegie Mellon University led to widespread use of Computer-Aided Design and Computer-Aided Manufacturing, which together have revolutionized much of the U.S. manufacturing industry. NSF was willing to encourage investigations into design problems that neither private firms nor federal mission agencies were willing to address.

While discovery and innovation underpin our global leadership in science and engineering, and consistently provide pathways for entrepreneurs, these activities are also first and foremost human endeavors. Thus, they demand the development of a highly skilled science, technology, engineering, and mathematics (STEM) workforce. NSF strives to ensure that students from diverse backgrounds, including women, underrepresented minorities, and persons with disabilities, have sufficient opportunities to engage in empowering learning experiences and inspiring research, no matter their economic circumstances. Sustaining such a world-class workforce is critical.

Federal investments in fundamental science and engineering and STEM training are increasingly important to help establish U.S. leadership in next-generation technologies, especially as other nations intensify their support of research, development, and education. It is crucial that we

measure up due to unprecedented global competition for the world-class talent who generate innovative scientific ideas and make up the technical workforce. Despite the constrained budget environment, we must make reasonable investments to secure our nation's future prosperity.

NSF will continue its role as the nation's innovation engine. The fuel for that engine is fundamental research. Scientific research, with its long-term perspective, strong emphasis on disciplinary excellence, and multi-disciplinary interactions, is a critical foundation for both transformational science and economic competitiveness. For all these reasons, the FY 2013 Budget Request provides increased support for the core fundamental research programs across NSF.

The NSF FY 2013 Budget Request

Budget Rationale

The NSF FY 2013 Budget Request presents a carefully-targeted portfolio of innovative investments that provides increased support for fundamental research in all fields of science and engineering. This core research, which constitutes the largest share of NSF expenditures, lays the foundation for progress in science and technology and enhances our ability to address emerging challenges in areas such as advanced manufacturing, clean energy technologies, cybersecurity, and STEM education.

One NSF Framework

A major emphasis in FY 2013 is the OneNSF Framework, which aims to enable seamless operations across organizational and disciplinary boundaries. OneNSF empowers the Foundation to respond to new challenges in a changing global environment, leverages resources and opportunities for maximum impact, and provides leadership to establish innovative practices, programs, and paradigms that advance scientific knowledge and science, technology, engineering, and mathematics (STEM) education. The OneNSF Framework encompasses a set of investments that create new knowledge, stimulate discovery, address complex societal problems, and promote national prosperity. The OneNSF Framework includes the following investments:

Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS) is a $257.42-million investment that will transform static systems, processes, and edifices into adaptive, pervasive "smart" systems with embedded computational intelligence that can sense, adapt to, and react to changes in the environment. The smart systems of tomorrow, created through CEMMSS, will vastly exceed those of today in terms of adaptability, autonomy, functionality, efficiency, reliability, safety, and usability. CEMMSS brings together researchers and educators from the areas of advanced manufacturing, materials science, cyber-physical systems, and robotics to build an integrated community of interest and stimulate new directions in research.

In the FY 2013 Budget Request, CEMMSS research includes $148.90 million for advanced manufacturing, which includes NSF participation in areas of national importance such as cyber-physical systems and advanced robotics research; materials processing and manufacturing; and advanced semiconductor and optical device design. Advanced manufacturing research invests in emerging technologies that promise to create high quality manufacturing jobs and enhance our global competitiveness. NSF is an agency partner in the President's **Advanced Manufacturing Partnership.**

NSF has a long history of investments in cyberinfrastructure. **Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21)** aims to more deeply address a highly science-driven integration of cyberinfrastructure (CI), supporting development of new statistical, mathematical, and computational methods, algorithms, and tools, as well as the cultivation of the next generation of computational and data-enabled researchers who prototype, develop, and use CI in all disciplines. In FY 2013, NSF will invest $106.08 million in this program.

The **NSF Innovation Corps (I-Corps)** is a public-private partnership to accelerate the movement of research results from the lab to the marketplace by establishing opportunities to assess the readiness of emerging technology concepts for transitioning into valuable new products. I-Corps will bring together technological, entrepreneurial, and business expertise and mentoring to move discoveries toward commercialization, thus facilitating the downstream development of technologies and processes from NSF-sponsored fundamental discoveries. Initially launched in FY 2011, NSF will invest $18.85 million in FY 2013.

Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) integrates NSF's existing interdisciplinary efforts with a suite of new Foundation wide activities. INSPIRE encourages research that involves multiple disciplines, connects disciplines, or creates new disciplines. It aims to widen the pool of prospective discoveries that may be overlooked by traditional mechanisms. The NSF Request for INSPIRE in FY 2013 is $63.0 million.

Cybersecurity vulnerabilities in our government and critical infrastructure are a risk to national security, public safety, and economic prosperity. **Secure and Trustworthy Cyberspace (SaTC)** is a $110.25 million investment that aligns NSF's cybersecurity investments with the four thrusts outlined in the December 2011 national cybersecurity R&D strategy, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program*. SaTC directly addresses the critical Administration priority of cybersecurity issues by supporting research and education that seeks to protect the nation's critical information technology infrastructure, including the Internet, from a wide range of threats to its security, reliability, availability, and overall trustworthiness. SaTC also addresses the social, behavioral and economic aspects of cybersecurity.

In FY 2013, NSF will invest $355.38 million in **Clean Energy**. NSF's clean energy investments include research related to sustainability science and engineering, such as the conversion, storage, and distribution of diverse power sources (including smart grids), and the science and engineering of energy materials, energy use, and energy efficiency. Some of NSF's investments in clean energy are supported through the FY 2013 NSF investment of $202.50 million in **Science, Engineering, and Education for Sustainability (SEES).** SEES focuses on targeted programs that promote innovative interdisciplinary research to address pressing societal issues of

clean energy and sustainability. Specifically, SEES will address a wide range of highly complex challenges including sustainable energy pathways; agricultural and environmental sustainability; sustainable chemistry, engineering, and materials; water scarcity; ocean acidification; natural disaster prediction and response, and sustainable coastal and Arctic systems.

The Intersection of Research and Education

Efforts to maintain national science and technology preeminence in a fiercely competitive global environment rest upon a highly educated workforce. The NSF FY 2013 Budget Request continues NSF's long history of support for the next generation of leaders in science, technology, and innovation. The suite of educational investments builds on the recognition that science and engineering talent is the foundation of America's future. Areas of educational investments run the spectrum from early learning to college completion.

K-16 Math Education: As part of the nation's strategic plan in STEM education, NSF is partnering with the Department of Education (ED) to launch an evidence-based effort to improve K-16 mathematics education and knowledge building. This new endeavor will support researchers and educators who have the greatest potential to improve mathematics learning. In FY 2013, NSF's Directorate for Education and Human Resources (EHR) and ED will each contribute $30.0 million. EHR's contributions will be through support for the Discovery Research K-12 (DR K-12) and Transforming Undergraduate Education in STEM (TUES) programs.

Transforming Undergraduate Education in STEM (TUES) aims to improve the quality of undergraduate STEM education. TUES research will help undergraduate teaching keep pace with advances in disciplinary knowledge, and underpin the creation of new learning materials, teaching strategies, faculty development, and evaluation to directly impact education in practice. In FY 2013, NSF will invest $61.46 million in TUES.

Expeditions in Education (E^2) is a new $49.0 million interdisciplinary effort that establishes a partnership between the Directorate for Education and Human Resources (EHR) and other research directorates and offices. E^2 aims to ensure that all of NSF's education and workforce investments are drawing on the latest STEM educational theory, research, and evidence. By incorporating cutting-edge science and engineering education, E^2 will improve learning in science and engineering disciplines and enhance the preparation of a world-class scientific workforce.

The **Widening Implementation and Demonstration of Evidence-Based Reforms (WIDER)** program, funded at $20.0 million in FY 2013, is an education research and development program that will modernize the way undergraduate students, including non-STEM majors, are taught and learn general science and mathematics. WIDER will explore how to achieve widespread sustainable implementation of evidence-based undergraduate instructional practices to improve student outcomes.

In FY 2013, NSF will invest $25.0 million to continue to support the **Federal Cyber Service: Scholarship for Service (SFS)** program to increase the number of qualified students entering the fields of information assurance and computer security. SFS will increase the capacity of the United States higher education enterprise to continue to produce professionals in these fields to meet the needs of our increasingly technological society. SFS directly addresses the Nation's increasing need for innovative solutions to cybersecurity concerns.

The **Advanced Technological Education** program focuses on education for high-technology fields, with an emphasis on two-year colleges to produce well-qualified technicians for existing and emerging high-technology fields. For FY 2013, the NSF Request is $64.0 million.

Continued Investment in American Innovation and Entrepreneurship:

The Faculty Early Career Development program (CAREER) develops the future scientific and technical workforce through support of young faculty who are dedicated to integrating research with teaching and learning. In FY 2013, NSF will invest $216.49 million to support approximately 40 more CAREER awards than in FY 2012, for a total of 440 new awards. The CAREER portfolio includes projects that range across all fields of science and engineering supported by the Foundation, including high priority fields such as clean energy, climate change, STEM education, and cybersecurity.

The Graduate Research Fellowship program (GRF), funded at $242.98 million in FY 2013, supports the development of students and early-career researchers in order to cultivate the next generation of STEM professionals. In FY 2013, 2,000 new fellowships will be awarded, maintaining the doubling of new fellowship awards achieved in FY 2010. To address inflationary pressures on the long-stagnant GRF stipend level, the FY 2013 Request increases the stipend to $32,000.

Science and Technology Centers (STCs) are funded in FY 2013 at $74.39 million. In FY 2013, a new cohort of STCs will be initiated (totaling $25.0 million) that will continue the tradition of conducting world-class research through partnerships among academic institutions, national laboratories, industrial organizations, and/or other public/private entities, and via international collaborations. STCs provide an innovative way for researchers to conduct investigations at the interfaces of disciplines and to invest in high-risk, potentially transformative science.

Experimental Program to Stimulate Competitive Research (EPSCoR) assists NSF in its mandate to promote scientific progress nationwide. EPSCoR effects lasting improvements in the research capacity of institutions in participating jurisdictions to promote broader engagement at the frontiers of discovery and innovation in science and engineering. The FY 2013 investment for EPSCoR is $158.19 million.

Enhancing Access to the Radio Spectrum (EARS), begun in FY 2012, continues to partner the Directorates for Engineering, Computer and Information Science and Engineering, Mathematical

and Physical Sciences, and Social, Behavioral, and Economic Sciences in supporting the basic research that funds research and development of spectrum-sharing technologies. NSF proposes an investment of $50.50 million for FY 2013.

World Class Scientific Infrastructure

The world-class equipment and facilities that NSF supports are essential to the task of discovery. All of the projects in the Major Research Equipment and Facilities Construction account undergo major cost and schedule reviews, as required by NSF guidelines. In FY 2013, NSF will continue support for the construction of the following four projects.

Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO). A planned upgrade of the existing Laser Interferometer Gravitational-Wave Observatory (LIGO), AdvLIGO will be ten times more sensitive, powerful enough to approach the ground-based limit of gravitational-wave detection. The FY 2013 investment is $15.17 million.

Advanced Technology Solar Telescope (ATST). ATST will enable study of the sun's magnetic fields, which is crucial to our understanding of the types of solar variability and activity that affect Earth's civil life and may impact its climate. The FY 2013 investment is $25.0 million.

National Ecological Observatory Network (NEON). NEON will consist of geographically distributed field and lab infrastructure networked via cybertechnology into an integrated research platform for regional to continental scale ecological research. The FY 2013 investment is $91.0 million.

Ocean Observatories Initiatives (OOI). OOI will enable continuous, interactive access to the ocean via multiple types of sensors linked by cutting-edge cyberinfrastructure, which will produce never-before-seen views of the ocean's depths. The FY 2013 investment is $65.0 million.

Excellence in Operations

NSF emphasizes the agency's desired outcome of attaining excellence in all aspects of its operations. Thus, performing as a model organization, one of NSF's three strategic goals, underpins NSF programmatic activities and encompasses all the agency's management activities. The Model Organization goal also includes support for the activities of the Office of Inspector General (OIG) and the National Science Board (NSB), which are provided in separate appropriations.

Workforce Development. The FY 2013 budget request includes $209.47 million, or $6.56 million over the FY 2012 Estimate, for funding NSF's federal workforce. The Request will

support 1,352 full-time equivalents (FTE), an increase of 25 over the FY 2012 Estimate allocation of 1,327 FTE.

iTrak. FY 2013 is the first year of iTRAK implementation. iTRAK will transition NSF from its legacy financial and property management systems to a fully integrated financial management solution. In FY 2013, the total Request for iTRAK is $11.70 million.

Efficient Management

NSF's FY 2013 Request follows a thorough examination of programs and investments across NSF to determine where the potential exists for more innovative investments. As good stewards of the public trust, we have made tough choices to reduce or eliminate lower priority programs, identified opportunities to leverage resources for maximum impact, and held the line on NSF's operating expenses.

This Request includes several recommended cuts and consolidations.

Computer and Information Science and Engineering Research Programs: Three programs within the Directorate for Computer and Information Science and Engineering (CISE) are eliminated since they have reached their planned endpoints and have achieved their original goals. These programs are: Network Science and Engineering (NetSE); Social-Computational Systems; and the Interface between Computer Science and Economic & Social Sciences (ICES). Support for these research areas will be absorbed into CISE core programs.

Cyber-Enabled Discovery and Innovation (CDI): NSF eliminates funding for the agency-wide CDI program, as the program has reached its planned conclusion and has achieved many of its original goals. Funding in FY 2013 will be redirected to support new efforts in two NSF cross-agency investments (CEMMSS and CIF21) that will build on the accomplishments made in the CDI program.

Mathematical and Physical Sciences Research Programs: Four programs within the Directorate for Mathematical and Physical Sciences (MPS) are eliminated because they overlap with larger core disciplinary programs or they have achieved their original goals. Two programs are eliminated as they are no longer needed as stand-alone programs: Mathematical Physics and Grid Computing. Research conducted under the third program, Cultural Heritage Science, will be funded through regular MPS disciplinary programs. Lastly, the CHE-DMR-DMS Solar Energy Initiative (SOLAR) will be subsumed within the broader framework of NSF's SEES investment through the Sustainable Energy Pathways solicitation.

Nanoscale Science & Engineering Centers (NSECs): NSF reduces support for the NSEC program because the state of the research in this area has matured significantly and the research should advance more rapidly in a different, more use-inspired research center program. Several NSEC grants may transition to the Nanosystems Engineering Research Centers (NERCs) as the nano-devices and processes created at graduating NSECs move to the systems level and potential

commercialization. NSF will continue to support eleven continuing NSECs in FY 2013 including the Nanomanufacturing ERC.

Public Outreach terminations: NSF eliminates two small stand-alone public outreach programs because they lack rigorous evaluation and are duplicative of the larger, well-established peer-reviewed Advanced Informal STEM Learning program (formerly, the Informal Science Education program). The eliminated programs are: Communicating Science Broadly and Connecting Researchers with Public Audiences.

Conclusion

With intense global competition for knowledge and talent, we must focus our attention on finding the sophisticated solutions that will ensure a prosperous, secure, and healthy future for the nation and the world. Robust NSF investments in fundamental science and engineering research and education have returned exceptional dividends to the American people, expanding knowledge, improving lives, and ensuring our security. To keep those benefits flowing, we need to constantly replenish the wellspring of new ideas and train new talent while serving as good stewards of the public trust. That is the fundamental and continuing mission of NSF.

Mr. Chairman and members of the Subcommittee, I hope my testimony explains how the Foundation plays a vital role in ensuring that America remains at the epicenter of the ongoing revolution in research, innovation, and learning that is driving 21st century economies. More than ever, the future prosperity and well being of Americans depend on sustained investments in our science and technology. NSF has been and continues to be central to this endeavor. The FY 2013 Budget Request for NSF clearly acknowledges NSF's pivotal role in ensuring America's future STEM leadership and economic wellbeing.

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

Chairman BROOKS. Thank you, Dr. Suresh.

I now recognize our second witness, Dr. Bowen, for five minutes.

STATEMENT OF DR. RAY BOWEN, CHAIRMAN, NATIONAL SCIENCE BOARD

Dr. BOWEN. Chairman Brooks, Ranking Member Lipinski, and Members of the Subcommittee, I appreciate the opportunity to testify before you today in support of the National Science Foundation budget request for fiscal year 2013. I am Ray Bowen, Chairman of the National Science Board and President Emeritus of Texas A&M University. I am also a Distinguished Visiting Professor at Rice University.

Before I begin my testimony, I would like to take a short moment to say a few words about the Board's working relationship with the NSF's senior management. Over the past year and a half, the Board has had the pleasure of working with our new Director, Subra Suresh. Dr. Suresh has brought fresh ideas to the Foundation, many of which are incorporated in the budget request before you. Board members appreciated having immediate access to the Director and all of his staff, and as a result we have developed a close working relationship. With the Board members representing the science, engineering, and education community around our country, we think this collaborative relationship is serving our Nation well.

My testimony today will emphasize a growing concern of the Board concerning the Nation's science and technology enterprise. The Board has a 40-year plus history of investigating indicators that drive innovation and discovery through its biannual report to the Congress and the President called, "Science and Engineering Indicators."

These footage have documented the critical nature of science and technology investments to America's long-term economic growth and quality of life. In the recently-released "Science and Engineering Indicators 2012," the R&D capacity trends demonstrate that nations worldwide are relying on innovation to drive progress. The data indicate that the United States remains a global leader in supporting science and technology research and development.

But other countries are now heavily investing in science and technology, having realized the significant returns. As reported in the "Indicator's 2012," the United States has lost 28 percent of its high technology manufacturing jobs over the last decade. The economic recession in 2001 and 2008 and more efficient manufacturing processes have no doubt contributed to this decline.

But other contributing factors include the growth of foreign investments in research and development and resulting increase in foreign research and development capacity. While the U.S. remains the overall world leader in high-technology manufacturing, this lead is shrinking. The NSF budget request for fiscal year 2013 reflects a clear understanding that investments in science, technology, and education are critical investments that will continue to build America far into the future.

For the budget request before you today one specific area I would like to highlight and that is the Foundation's Agency Operations and Award Management account. The AOAM account provides the

fundamental framework through which the Foundation's science and engineering research and education programs are administered. AOAM funding covers NSF's scientific, professional, and administrative workforce, the physical and technological infrastructure necessary for a productive work environment, and the essential business operations critical to efficiently managing NSF's administrative processes. To sustain its excellence and its efficient management, the Board fully urges full funding of the NSF's AOAM account.

Over its 60-year plus history, NSF's investments have unwritten a wealth of research that has directly and indirectly benefited the American economy and the general public, much of which—there is much that remains to be done. I understand that investments in science and technology compete with a host of other deserving funding priorities, but maybe attempting to forego the long-term investments in the face of short-term challenges, neglecting the scientific research and education now may have serious consequences to our country as the data gathered from our "Indicators" report illustrates.

On behalf of the Science Board and the STEM research and education communities I would like to thank Members of this Subcommittee for your long-term support of the National Science Foundation. We look forward to continuing that long-term relationship.

Thank you.

[The prepared statement of Dr. Bowen follows:]

PREPARED STATEMENT OF DR. RAY BOWEN, CHAIRMAN, NATIONAL SCIENCE BOARD

Testimony of
Dr. Ray M. Bowen, Chairman
National Science Board

Before the Subcommittee on Research and Science Education
House Committee on Science, Space, and Technology
February 28, 2012

Chairman Brooks, Ranking Member Lipinski, and members of the Subcommittee, I appreciate the opportunity to speak with you today in support of the National Science Foundation's budget request for Fiscal Year 2013. I am Ray Bowen, Chairman of the National Science Board and President *Emeritus* of Texas A&M University, and I am also a Distinguished Visiting Professor at Rice University.

Before I begin my testimony, I would like to say a few words about the Board's working relationship with NSF senior management. Over the past year and a half, the Board has had the pleasure of working with NSF's Director, Subra Suresh. Dr. Suresh has brought fresh ideas to the Foundation, many of which are incorporated in the Budget Request before you. All of the Board members have appreciated the close relationship we've developed with Dr. Suresh and his senior management team. We've had immediate access to the Director and all of his staff, and this working relationship has developed into quite a strong bond. With the Board members representing the science, engineering, and education community writ large, this collaborative relationship has served the Nation well.

Introduction

On behalf of the National Science Board, I would like to thank members of the Subcommittee for your enduring support of the National Science Foundation and its investment in an extensive portfolio of research and education enterprises spanning broad and cross-cutting areas of science, technology, engineering, and mathematics. In keeping with its vision to facilitate *a nation that*

capitalizes on new concepts in science and engineering and provides global leadership in advancing research and education, the Foundation has taken great care in the development of its Fiscal Year 2013 Budget Request. Specifically, the Request sets out to reiterate the Foundation's primary role in supporting basic research and education.

The National Science Foundation Act of 1950 created the Foundation and the National Science Board and established that NSF's primary mission is to support basic research. Specifically, the purpose of the National Science Foundation as stated in its enabling legislation is "to initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs at all levels in the...sciences... to support scientific and educational activities and to appraise the impact of research upon industrial development and upon the general welfare..."

For more than 60 years, the National Science Foundation has played a central role in innovation by catalyzing the development of fundamental ideas across the frontiers of science and engineering knowledge and supporting the people who generate them. As the only federal agency dedicated to the support of basic research and education in all fields of science and engineering, NSF is positioned to strategically stimulate innovative research that connects the science and engineering enterprise with potential economic, societal, and educational benefits. NSF's high-risk, potentially transformative investments will continue to lead the way for the important discoveries, the education of the future science and engineering innovators, and development of cutting-edge technologies that will help keep our Nation globally competitive, prosperous, and secure.

Fiscal Year 2013 Budget Request

The National Science Foundation's FY 2013 Budget Request reflects careful and wise decision-making of the commitment of federal funding toward innovative, targeted investments that closely align with both agency and Administration priorities. The Request totals $7.373 billion, an increase of $340 million or 4.8 percent over the FY 2012 Estimate, consistent with the Administration's commitment to doubling funding for NSF and other key basic research agencies. Specifically, the NSF 2013 Budget Request reflects a clear understanding that

investments in science and technology are investments that will build America's future. This request acknowledges the critical nature of science and technology to America's long-term economic growth. Federal support for research and education across science and engineering fields is critical, particularly now, in our current economic environment. This is especially true given that private firms have decreased their investments in long-term research and development projects.

The Board is especially supportive of those programs that reach across disciplines to bring fresh approaches from differing perspectives to tackle some of the greatest challenges of our time. Many of those programs are part of the agency's OneNSF initiative. Throughout its history of developing successful collaborations with researchers in many disciplines, NSF is in the best position to bring together the science community to address seemingly intractable problems at the frontiers of knowledge. The details of these efforts are best left to Dr. Suresh and the agency's senior management to describe.

For the budget request before you today, one specific area I would like to highlight is the Foundation's Agency Operations and Award Management account, also known as the AOAM account.

The AOAM account provides the fundamental framework through which the Foundation's science and engineering research and education programs are administered. AOAM funding covers NSF's scientific, professional, and administrative workforce; the physical and technological infrastructure necessary for a productive, safe and secure work environment; and the essential business operations critical to managing NSF's administrative processes and providing high-quality customer service to the public. To sustain its excellent management, the Board urges full funding for NSF's AOAM account.

For the National Science Board Office, the Board requests $4.44 million, level with our budget for FY 2012. This will allow the Board to continue its national policy role and its oversight role for NSF.

Many breakthroughs in research and development could not have been realized without the Nation's investment in science and engineering. Imagine our world without some of the National Science Foundation supported discoveries and inventions that we now take for granted, such as Magnetic Resonance Imaging, more commonly known by its acronym MRI, a critical tool in helping physicians diagnose a wide array of illnesses, and the internet on our iPhones or BlackBerrys. These kinds of innovations and inventions are critical to the economic well being of our Nation. In some instances just one discovery can spawn the development of entirely new and prosperous market sectors. Our Nation needs this investment, now more than ever.

U.S. Leadership in Science and Technology

In the recently released *Science and Engineering Indicators Digest 2012* publication, the Board elected to emphasize Research & Development (R&D) capacity and outputs of the United States and how global trends affect them. These trends demonstrate that increasingly economies worldwide rely on innovation to progress, thus driving the increased global dependence and thirst for knowledge. The data indicates that the United States remains the global leader in supporting science and technology (S&T) research and development, but other countries are catching up, in recognition of the potential return on investments in science and engineering.

As reported in *Indicators 2012*, the United States lost 28 percent of its high-technology manufacturing jobs over the last decade; this represents 687,000 jobs since 2000. While economic recessions in 2001 and 2008 and more efficient manufacturing processes have contributed to this decline, other contributing factors include the growth of foreign investment in R&D and the resulting increase in foreign R&D capacity. Further, the globalization of supply chains enables lower skilled work to be performed in more remote locations at reduced labor costs. While the U.S. remains the overall world leader in high-technology manufacturing, its lead is shrinking, and China has emerged as a world leader in high-technology trade. At this juncture, the United States is falling alarmingly close to being overtaken by rapidly increasing Asian investments in knowledge- and technology-intensive industries to bolster their economies.

Public Research Universities and Colleges

Universities and colleges are the key performers of the Nation's basic research, performing more than half of U.S. basic research (53 percent) in 2009. Support from the federal government makes up about 60 percent of academic research and development funding.

In the 2012 edition of *Indicators*, the Board also sought to highlight trends in state funding of research universities. The Board is concerned with the overall decline in funding for these institutions. *Indicators* show that between 2009 and 2011, 35 out of the 50 states reported reductions in state appropriations for higher education. This reduction, coupled with the decline that followed the 2001 recession, resulted in a 10 percent decline for the decade after accounting for inflation. The reduction also coincided with an increase in enrollment. As a result, per-student funding, after inflation, declined by 20 percent from 2002 to 2010.

The academic basic research enterprise provides the mentoring and experience essential to the training of new scientists and engineers. Significantly, the Nation's public research universities graduate a major share of undergraduate and graduate students majoring in key areas of science, technology, engineering, and mathematics. These graduates are essential participants in the Nation's science and engineering workforce and have a crucial role in fostering the Nation's economic development.

NSF's National Center for Science and Engineering Statistics conducted a public opinion poll surveying Public Attitudes Toward and Understanding of Science and Technology. Since 1985, NSF surveys have asked Americans whether, "even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government." In 2010, 82% agreed or strongly agreed with this statement. Agreement with this statement has ranged from a low of 76% in 1992 to a high of 87% in 2006. These data indicate that a significant portion of the American public understands the link between supporting basic research and our Nation's economic well-being.

The Globalization of Higher Education

The developed world's lead in higher education has declined dramatically as the number of students in developing countries earning science and engineering degrees has risen. In 2008, the U.S. produced only four percent of the world's engineering degrees, while 56 percent were awarded in Asia, including a third in China. About 30 percent of all university undergraduate degrees earned in China were in engineering.

The number of natural science and engineering degrees rose in China from 280,000 to one million between 2000 and 2008, compared to 248,000 in the United States. In addition, the number of natural sciences and engineering doctorates awarded by Chinese universities has more than tripled since 2000. With 26,000 awarded in 2008, the number of Chinese doctorates now exceeds the number earned in the United States. It should also be noted that a large share of U.S. doctorate degrees is awarded to foreign students. In 2009, 44 percent of the 24,700 U.S. natural sciences and engineering doctorates were awarded to temporary visa holders. For engineering doctorates, 57 percent were awarded to foreign students.

With the world leadership role of the United States in science and engineering increasingly challenged, the National Science Foundation continues to do its part in maintaining the preeminence of the United States in science and engineering. The National Science Foundation's basic research mission continues to be the highest priority for the Foundation today.

National Science Board Activities

As part of NSF's policy-setting process and its role as advisor to Congress and the President on national science and engineering issues, the Board identifies areas for review and further examination through the establishment of task forces dedicated to an identified issue or topic. I'd like to briefly mention three of our most recent studies.

Merit Review Criteria

In May of 2010, the National Science Board initiated a review of the Foundation's Merit Review Criteria, thereby establishing the Task Force on Merit Review. It had been more than a decade since the two criteria were implemented and the Board felt, as representatives of the research

community, that review of the criteria was critical to ensuring the continued integrity of the peer review process. This is particularly timely given the projected increase in the number proposals submitted annually.

Every proposal submitted to NSF is evaluated as part of the Merit Review process and with respect to two important Merit Review Criteria—Intellectual Merit of the project and the Broader Impacts of the work to the public.

The importance of considering potential broader impacts in the process of deciding which projects to fund was re-emphasized in the America COMPETES Reauthorization Act of 2010. This legislation identifies a number of socially relevant outcomes, to which NSF-funded research contributes. Similarly, the NSF Strategic Plan emphasizes the value of broader impacts of scientific research, beyond the intrinsic importance of advancing scientific knowledge.

Based on the Task Force's analyses, the NSB concluded that the two current Merit Review Criteria of Intellectual Merit and Broader Impacts remain appropriate for evaluating NSF proposals. However, the Board concluded that revisions were needed, both to draw a clearer connection of the Criteria to core principles and to better articulate the essential elements of each criterion. The Foundation is currently working to implement this guidance.

The Board's review of the criteria was a necessary undertaking to ensure that the investments in research and education initiatives are in keeping with the National Science Foundation's strategic goals for support of science and engineering research and education.

Data Policies

The progress of science and engineering has always been dependent on the collection of data. A core expectation of the scientific method is the documentation and sharing of results, underlying data, and methodologies. The increasing ease with which digital research data are gathered, processed, analyzed, and disseminated has expanded the scale, scope, and complexity of science and engineering data collections and highlights the need for improved research data policies. A mandated responsibility of the National Science Foundation is "to provide a central

clearinghouse for the collection, interpretation, and analysis of data on scientific and engineering resources" ("National Science Foundation: Functions," Title 42 *U.S. Code*, Chapter. 16. Sec. 1862). Therefore, NSF is dedicated to improving and implementing policies that provide a strong and sustainable foundation for sharing and managing digital research data for the benefit of the science and engineering research community.

In February 2010, the Board chose data policies as another priority and established the Task Force on Data Policies under the Committee on Strategy and Budget. The task force was charged with the further refinement of NSF data policies to address key challenges and outline possible options to more effectively use digital research data to meet the mission of NSF. The work of the task force culminated in a final report from the National Science Board that presents key challenges and recommendations related to the sharing and management of digital research data generated by NSF-funded activities.

The Board's view on data policies is reflected in the report, which stresses that timely attention to digital research data sharing and management is fundamental to supporting U.S. science and engineering in the twenty-first century. The Board recognizes the evolving role of data in science and society and strong and sustainable data sharing and management policies as a critical national need.

Instrumentation Report

Another priority for the Board over this past year has been mid-scale instrumentation. The America COMPETES Reauthorization Act of 2010 (ACRA 2010) Section 507 directed the National Science Board (Board) to "…evaluate the needs, across all disciplines supported by the Foundation, for mid-scale research instrumentation…" and to report its findings and recommendations to the Congress. In identifying mid-scale instrumentation activities, the Board was guided by the language of the ACRA 2010 as those mid-scale instrumentation investments falling between the MRI and MREFC programs.

During calendar year 2011, the Board's Committee on Strategy and Budget directed its Subcommittee on Facilities to investigate the means and extent to which the needs of the

scientific community are being met by on-going and planned investments in mid-scale instrumentation. The Board's examination comprised an evaluation of mid-scale research instrumentation activities and funding approaches in each of NSF's Science and Engineering directorates and offices, and an analysis of anticipated mid-scale instrumentation needs across NSF-supported disciplines. The Board solicited input from these organizations regarding current mid-scale instrumentation activities, including projects, funding mechanisms, partnering, life cycles and anticipated demands for future mid-scale instrumentation within the science communities served by NSF.

Overall, the Board found that the current research infrastructure investments across the Foundation are in alignment with the Board's earlier recommendations on funding and prioritization, including for mid-scale research instrumentation. In particular, the Board found that NSF's current balance of small, medium and large instrumentation is sound, and that the variety of mechanisms by which NSF prioritizes, solicits, evaluates, and supports mid-scale instrumentation – both directly and indirectly through large centers and facilities – provides flexibility and vigor to NSF's efforts. Consequently, although the Board's evaluation points to the importance of continuing to strongly support mid-scale instrumentation, the Board does not recommend that NSF expand existing Foundation-wide programs or create a new Foundation-wide program for mid-scale instrumentation at this time. The Board will continue to work with NSF management and staff to capture, assess, prioritize and support anticipated needs for mid-scale instrumentation as part of NSF's research infrastructure investments.

Board Involvement in Budget Planning

The Board is intimately engaged in the development of the agency's Budget Request and related initiatives, which are featured in its annual Budget Request. The Board's involvement in the budget formulation process occurs primarily through its Committee on Strategy and Budget, which works with NSF senior leadership. The Board is involved with and kept apprised of the development of the budget every step of the way— from the initial planning stage for the next budget through informal discussions, numerous teleconferences, and final approval of the submission to the Office of Management and Budget. In working with the Foundation to determine priorities, the Board takes into account the priorities of the Administration and

Congress. We also bring our experience with the needs and readiness of the Nation's science and engineering community as a whole.

Conclusion

In closing, I'd like to reiterate that the outcomes of prior years of support have had positive effects on our Nation and its growth and prosperity, contributing directly to the economy and the creation of jobs in the United States. This 2013 Budget Request seeks to increase the efforts and results of this trend. Accordingly, the Board emphatically supports the National Science Foundation's focus on science, engineering, and educational investments as proposed in NSF's fiscal year 2013 Budget Request. The Board views this as a crucial and timely investment in our Nation's future.

The Board maintains support for the National Science Foundation's comprehensive and flexible portfolio of meritorious projects that have far reaching societal impacts. Flexibility in supporting a diverse portfolio enables the Foundation to identify and foster both fundamental and transformative discoveries within and among fields of inquiry. Preservation of the National Science Foundation's eminence as the Nation's premier agency supporting basic research and education in mathematics, science, engineering and technology is critical. Therefore, the Board strongly supports the President's Fiscal Year 2013 Budget Request for the National Science Foundation.

Chairman BROOKS. I thank the panel for their testimony. Reminding Members that Committee rules limit questioning to five minutes.

The chair at this point will open the round of questions. Normally the chair would recognize himself for the first five minutes, but in this instance I am going to swap times with Mr. Hultgren from the great State of Illinois.

Mr. HULTGREN. Thank you so much, Chairman, and thank you both for being here. I really appreciate that.

Dr. Bowen, I just wanted to start out, I have got several questions for both of you, so I wanted to go through some things kind of quickly.

You testified that the growth of foreign investment and R&D and resulting increase in foreign R&D capacity are contributing factors to the loss of 28 percent of domestic high technology manufacturing jobs over the last decade. Would you agree that there are some other contributing factors, many of which may be more critical of the loss of manufacturing jobs, or any jobs for that matter overseas? And wondered, R&D spending aside, what do you think is the major obstacle to American competitiveness today?

Dr. BOWEN. There are many factors, and it is much more complicated than my short statement would summarize. I come from a world where we invest a tremendous amount of confidence in the Nation's ability to respond with innovation given the fundamental investments in basic science. It is a long-term situation, and I realize there are short-term issues that need to be addressed.

I would make a plea for the support for the long-term basic research. I think it will pay off to our Nation.

Mr. HULTGREN. I agree with you. I am a huge supporter of basic scientific research. I feel like if we fail to do that we absolutely are failing our future as we do that.

Dr. Suresh, I wonder if I could ask you, NSF has been identified as the "only federal agency dedicated to the support of basic research as we are talking about in education and all fields of science and engineering." Do you believe that some of the more applied areas of research identified in *America COMPETES Reauthorization Act*, coupled with multiple Administration applied priorities for NSF for fiscal year 2013 budget request dilutes the funding for basic fundamental research, and wonder if you could please explain, and also Dr. Bowen, I would love to get your thoughts on that as well.

Dr. SURESH. So as you pointed out, Mr. Hultgren, NSF funds, NSF focuses primarily on basic science and engineering, but we also walk a very fine line between supporting core research, fundamental research, and research that may have a practical application where we provide basic knowledge, basic tools, basic technologies.

A very good example is robotics. If you take the National Robotics Initiative, which is about $70 million or so for the year, NSF's investment is about $28 million on an annual basis. That investment goes from mathematics to computer science, optimization, social and behavioral sciences, human machine interactions so a variety of fundamental tools, processes, technologies and basic understanding that the National Robotics Initiative and NSF foster. So

that is a very good example of an interplay between basic research and what may seem like an applied area.

Another example that I would like to point out going back to your first question for Dr. Bowen, in the 1970s NSF funded mathematical and process modeling, which at that time was viewed by even some of the mission agencies, and industries, as too academic. That support in the 1970s led to what we now know as rapid prototyping, which had a huge impact on American leadership in manufacturing in the '80s and '90s.

I think at NSF the boundaries are blurred between the continuum of basic research all the way to what may evolve to be a spectacular innovation.

Dr. BOWEN. If I could just add a small footnote to this, you asked very specifically do we think that the applied research investments are in some sense competitive with basic research. I would like to say no because I think that they play well together to reinforce each other. There are compromises and challenges in the budget that all of us understand. The one benefit of the basic research which we celebrate in my life as a university professor is the creation of the human resource, the young people that are going to invest long careers, both in applied as well as fundamental kinds of activity.

So I, again, would support that as well.

Mr. HULTGREN. And my fear is, again, that we are diluting that priority of basic scientific research that all of us are talking of how important that is.

One last question. Dr. Suresh, you described the new I–Corps initiative as "a public-private partnership to accelerate the movement of research results from the labs to the marketplace by establishing opportunities to assess the readiness of emerging technology concepts for transition into the valuable new products or into valuable new products." Please walk us through I–Corps, specifically how awardees are selected, how you avoid picking winners and losers, which is something I am very concerned about, and perhaps most importantly how this program falls within the basic research mission of the Foundation.

Dr. SURESH. I will be very happy to answer that, Mr. Hultgren. NSF supports approximately $6 billion of basic research every year, and it is our desire and our mission not to deviate from that goal. Having said that, NSF historically—going back to the 1970s—has taken the product or the output of fundamental research and extracted out of that the maximum value. A very good example is the SBIR Program. NSF was the first federal agency to start an SBIR Program. Now there are nine federal agencies to do that.

What we do in the I–Corps is at the end of an NSF-funded project or very near the end of an NSF-funded project, we ask the community to provide ideas on how to take the output of NSF-funded fundamental research, the basic discovery, and by giving the principle investigators a small amount of money over a short period of time, ask them does this basic discovery have the opportunity to go beyond publication, beyond a patent, perhaps to lead to a product, a process, a software, a tool that can have near-term or long-term benefit to the society.

And as I think the Ranking Member just mentioned, the I–Corps budget by design is a tiny, tiny fraction of the NSF budget, and I–Corps comes well before the foundation of a small business. So it is even more academic, more pre-business than SBIR. So it is well before the valley of death and what we call a ditch of death where ideas may not see the light of day because there is no opportunity. So that is the first goal of I–Corps.

It is absolutely not our intention to pick winners and losers. I–Corps does business the same way NSF does business. We want to fund the best ideas and the best people in the most transparent way through a gold standard peer review process, and that is what I–Corps will continue to do.

In the first round we funded 21 programs, and all initial indications are a good subset of those programs will go much beyond what I–Corps had intended. So we are very pleased with the initial indications.

The other idea of I–Corps is the vast majority of NSF-funded institutions in the country at the present time, either because of the geographical location or because of the lack of infrastructure, are not part of the innovation ecosystem of the country. They probably are isolated. They may not have the innovation infrastructure in their institutions. They may not have access to venture capitalists. Given that NSF in 2013 will support 285,000 individuals in the country to the tune of $6 billion, and we touch nearly 2,000 institutions in the country, we have an opportunity to use our stature, our reach, our scope to create a virtual infrastructure that brings together not only academics but also industry leaders, people who have had spectacular successes through innovation, and equally people who have failed so that we can learn lessons from them.

So and I believe that innovation is a contact sport, and by bringing our NSF-funded community, including students, in touch with this national ecosystem, we believe that we can extract much more value out of NSF investments into basic science and engineering.

Mr. HULTGREN. Again, I thank you both for being here. I just want to continue to work together, again, to have that focus of protecting, and I hear it from both of you, protecting that commitment to basic scientific research, especially in a time where dollars are so tight, to make sure that the priority is still there. So thank you.

Chairman, thank you so much for your graciousness, too, in allowing me to go over and allowing me to go first. So thank you so much. I yield back.

Chairman BROOKS. Thank you, Mr. Hultgren.

The chair now recognizes Mr. Lipinski of the great State of Illinois.

Mr. LIPINSKI. Thank you, Mr. Chairman. I think there must be something in the water there because the same two topics, manufacturing and I–Corps, that Mr. Hultgren had asked about I also want to ask some questions about.

I want to start with I–Corps, and perhaps this is an area that the chairman would considering having a hearing on so we can all learn more about what the I–Corps Program is and what the I–Corps Program is doing. I think the key, Dr. Suresh, you had—your experience with the Deshpande Center at MIT and for me one of the bottom lines with this is we have a lot of people doing great

research with, you know, NSF funding across the country, and scientists are not always the best at knowing how to take those ideas and create a business. And I think that is what I–Corps is trying to do to help them to be able to do that, give them the education, the contacts to be able to do that, and I think it is a really, as I said, potentially game-changing program.

I just wanted to ask briefly of Dr. Suresh, if you could talk a little bit about how you are going to expand this program, including where does private funding come into this, private investment since this is public-private?

Dr. SURESH. Thank you, Dr. Lipinski. So in the inner shell we wanted to start small, and we wanted to start with very small investments and a small cohort of funded projects last summer. The initial private engagement came from two non-profit foundations. One as you mentioned, the Deshpande of Massachusetts, and the other, the Kauffman Foundation of Kansas City. The Kauffman Foundation, as you know, has a lot of experience in this phase, and our idea would be to take the best practices of going from fundamental scientific discoveries to still staying in the technology development regime, not going to the business side but within that space try to identify how the ideas can move beyond publication or basic discovery.

So intentionally we have put in about $50,000 for initial awards. For the first 12 months our goal is to fund about 100 projects or so. So we announced 21 projects early on and used the RAPID mechanism so that we can identify them very quickly. RAPID mechanism is a mechanism that NSF has used effectively for quite some time. And we will have a second cohort of about 25 projects that will be announced before too long. So that is one part of it.

The other part is that our studies state we would like to have regional nodes of institutions that engage, that not only provide data expertise to the I–Corps Project as a virtual national network, but they will also help support other institutions.

The third part of the I–Corps mechanism is to develop a national cohort of mentors, maybe about 100 mentors or so, who will be regionally distributed and distributed in terms of their technological expertise. They will play a mentoring role to especially young faculty members at universities across the country.

The fourth component of this is that we will, using NSF's reach across the country and history and visibility, we would hope to bring NSF PIs in contact with leaders in industry, including small businesses from around the country. We have a variety of programs at NSF, the SBIR Program, Engineering Research Centers, IUCRCs, Partnership for Innovation. So all these programs can be leveraged to enhance the potential success of I–Corps.

Last but not least, one of the components of I–Corps is an educational experience. We have, as you mentioned, funded a center on innovation, especially at the undergraduate level, teaching entrepreneurship at Stanford University. We initially started with that mechanism to provide instructional opportunities and educational opportunities for I–Corps grantees to learn more about what it takes to go beyond just development of technology—how to pay attention to other factors that are critically important for the success of their innovation.

Mr. LIPINSKI. Thank you, Dr. Suresh, and I am actually out of time now. I just want to say I think the great potential for this being—I–Corps being a feeder for NSF's SBIR Program is definitely a great possibility.

With that I yield back. Maybe we will have a second round of questions I can get Dr. Bowen the advanced manufacturing.

Chairman BROOKS. Certainly, Mr. Lipinski, time permitting we will do that.

Let me now at this point go into the Chairman's comments and questions.

I want to emphasize that I have the highest degree of confidence in both Dr. Suresh, having visited the NSF, Dr. Bowen, in your desire to further basic research and America's intellectual capacity in that regard.

At the same time I have to temper that somewhat, though, with the very difficult financial condition our country is in. I have a background in economics, and I want to assure you that if we continue as a country on this path, there is 100 percent certainty that we will face a national insolvency and bankruptcy.

Hence, we have got to do everything we can to change the path that we are on. You have seen what is going on in Athens, Greece, Italy, and other nations around the world who are more advanced towards this insolvency than we are, and so everything we do has to be tempered in that regard.

To give you an idea of the risk to the National Science Foundation, which, again, I hold in very high regard, should there be this insolvency and bankruptcy, worse case scenario you all would be zeroed out because the Federal Government simply would not have the funds if other items, national defense, Medicare, Medicaid, Social Security ended up being the highest priorities of the Federal Government.

If just your share of the deficit were imposed on you, that would mean a cut of 36 percent in National Science Foundation funding. That is definitely not a good thing for the progress of our country. If I were in charge, and I am not, I am one person on, you know, a little pawn on a very large chessboard as seemingly most freshmen Congressmen are, you know, I would look at things like foreign aid. It is nice to help your friends and neighbors around the world, but at the same time you have to get your own financial house in order. And I mention this just as an example of priorities, but direct and indirect foreign aid is in excess of $60 billion. That is almost ten times what we spend on productive things like the National Science Foundation, and I use that as a comparison point.

So if I were in charge and able to cut elsewhere and reprioritize, I would be mildly surprised that you were asking only 4.8 percent increase in your budget. I would certainly strive for more, particularly in the context of the international competition that we face with basic research and how some of our competitor nations are seeking to strive to be in front of the United States of America on technological advances.

Certainly I say that with the community I come from as a background item. I am from Huntsville, Alabama, where we have a very high concentration of engineers, Ph.D.s, scientists, mathematicians, physicists, you name it. Huntsville basically being the birthplace of

America's space program and also if you are familiar with the Gee Whiz Bang High Tech weaponry you see on TV when we are engaged in conflicts around the world, well, most of those are born or created or contracted for out of Huntsville, Alabama. So we understand in my community the importance of basic research and the value there of.

That having all been said, Dr. Suresh, this question is for you. I applaud the Foundation for identifying programs for consolidation or elimination totaling $67 million. However, that is less than one percent of your current budget.

Given our current economic situation and when your budget request is asking for an almost five percent increase, are there other programs that are right for elimination, consolidation, or reduction? And what steps is the Foundation taking to make these fiscally-responsible changes?

Dr. SURESH. Thank you, Mr. Chairman, for your question.

NSF is a $7 billion agency with an overhead of six percent. It is an extremely lean, lean organization. If we cut anymore in this organization, it will go from lean to anorexic, and I think we are under danger of that. So that is the first point I would like to make.

The second point you heard not just from me before but from my predecessors, previous directors of NSF repeatedly, that NSF staff are extremely overworked at a time when the proposal pressure is very large. Last year we handled in excess of 55,000 proposals, and given that extreme overload, we managed to not only handle this and keep NSF and the scientific community at the forefront without any increase in workforce. In fact, even though we had cut $67 million, it has been extremely painful for us to see that we have to hold the line on the AOAM budget for fiscal year 2013. That effectively reflects a cut in our budget, especially at a time our staff are overworked. As Dr. Bowen mentioned it is a very important item. It is the backbone of all our activities.

We have taken great pains to go through the budget very, very carefully, put investments in areas where we can keep the American scientific enterprise and the workforce at the forefront while trying to be as fiscally responsible as possible. And so this is, this budget reflects that sentiment.

Chairman BROOKS. Thank you, Dr. Suresh. I would encourage you to continue to examine the NSF expenditures to see if there are any other duplications or wastes that can be ascertained, again, in light of the budget circumstances we face.

I see I am over time, but inasmuch as I am going to allow others to have second rounds of questions, I am going to ask one more before I defer to the next Congressman.

Dr. Bowen, as I mentioned, Congress is faced with many difficult funding decisions in our current economic situation. Every committee is hearing similar pleas from education to transportation and from energy to defense. Federal funding cuts are likely a reality over the next few years.

How would you suggest we look at reigning in government expenditures across the board, and how do we prioritize programmic funding for the Foundation?

Dr. BOWEN. Thank you. Your question has broad dimensions, and it is a complicated one. It is one that we on the Science Board discuss among ourselves frequently. We are very pleased in the year and a half that Dr. Suresh has been our director that he came on board addressing that same kind of concern, and he is looking seriously across the Foundation at all of its programs trying to set priorities.

In some measure while $7 billion is a huge amount of money for small activity, and we think, in fact, we produce a large result, other major possible consequences are the kinds of investments that we have been allowed to make throughout our history.

So we would always plead that we would be allowed to continue that, but if it were to be the case that we had to come back with a more difficult budget situation than currently is present, the Foundation and the Board itself would work diligently to sort of set those priorities, and we would be reinforcing the already serious background work our director and his senior staff have done. I don't have the simple solution in terms of the shape that might actually take, but, in fact, you can depend on full cooperation and energy of the Board to work with the Foundation to achieve whatever parameters are set for us in terms of our budget.

Chairman BROOKS. Thank you, Dr. Bowen.

At this time the Chair recognizes Mr. Tonko of New York.

Mr. TONKO. Thank you, Mr. Chair. Dr. Suresh, for many students, community colleges are the gateway to higher education, affording them the most, the greatest opportunity economically for that stretching of their education career. And community colleges then also provide them that step to the four-year university. They have also had a long history of training and retraining people to allow them to upgrade their job skills.

Which of the NSF education initiatives provide support for our community colleges?

Dr. SURESH. There are a number of activities that we have, but one of the programs that specifically targets community colleges is the ATE Program with a request—budget request in 2013 of $64 million. ATE stands for Advanced Technological Education, and so that is one program that I want to mention.

The other broader program is the EPSCoR Program because in many of the EPSCoR states, perhaps community colleges, are more of a gateway to the educational enterprise for the citizens. That is another vehicle that we have. So those are two examples that I can give you.

Mr. TONKO. And the NSF Innovation Corps Program sounds similar to the mission of the Small Business Innovative Research Program, SBIR. Can you discuss the relationship between the two programs so that we can better understand the separate issues they are designed to address?

Dr. SURESH. I will be happy to. The Innovation Corps Program is designed in a space that comes way before a small business is formed. Our goal for the Innovation Corps program solicitation is to address those projects that have just completed or that are about to complete an NSF-funded basic research effort. So we give them a very small amount of money, something on the order of about

$50,000 for two months and ask them to look at what is the potential for the basic discovery to go beyond just a basic discovery.

And this comes way before SBIR. So our hope would be one of the metrics of success for the Innovation Corps would be that many of the I–Corps projects would matriculate to an SBIR application, not just at NSF but even at other federal agencies. Maybe they will receive VC funding or some other venue.

So that is one of the goals. So the Innovation Corps is much more towards basic research than the SBIR Program.

Mr. TONKO. Okay, and then when you talk about research, I noted that NSF has allocated like 300 million toward clean energy research, and I am pleased to see our President is focusing on efficiency and clean energy because in my opinion energy efficiency ought to be our field of choice. So where—can you tell us how you are coordinating with the Department of Energy on these research programs as they relate to clean energy?

Dr. SURESH. So we have frequent conversations not just with Department of Energy, with other federal agencies. There are a number of mechanisms that we have. One vehicle is through the initiatives in which we co-fund. We have frequent conversations. Our program officers have a lot of frequent contact with program officers from our sister agencies in Washington.

The other mechanism we have is the National Science and Technology Council, which I co-chair along with Dr. Francis Collins from NIH and Dr. Carl Wieman from OSTP, the Committee on Science. The Committee on Science is a forum that brings together principals from many different agencies in Washington, and that is where we compare notes.

With respect to clean energy and the NSF context, there is always a basic research—primarily a basic research component of this. Clean energy could mean for us, for example, new materials to design a panel for solar energy, or it could be new material for solar cells. It could involve new engineering models to understand fluid mechanics, whether it is wind or water and so forth. So NSF's focus is always basic science, even in the clean energy context.

One other point I would like to make is NSF is unique in that it supports all fields of science and engineering, so as an agency we are uniquely positioned, especially in the energy space, to bring in perspectives from social, behavioral, and economic sciences to bear on perspectives from natural sciences. And that interplay is very unique and very important, and NSF plays a very critical role. This is something that we have talked to our colleagues in the Department of Energy about how we can collaborate.

Mr. TONKO. Thank you, Dr. Suresh, and I believe I am out of time, so thank you, Mr. Chair.

Chairman BROOKS. Thank you, Mr. Tonko.

The Chair next recognizes the Chairman of the Science, Space, and Technology Committee, Mr. Hall, for remarks.

Chairman HALL. Mr. Chairman, thank you. I will be very brief because I don't know what remarks have been made or answers given, but I just want to thank you and for whoever selected these two gentlemen here. It is the best job of selecting I have known in a long, long time. I know to have the director of the National Science Foundation here and I thank you for your recent letter of

support, and of course, Ray Bowen, I have known him and known of him forever, and that is a long time for a guy like me. But he was President of Texas A&M, and he is now associated with Rice University. I probably—I could have got into A&M, might could have got out, but I couldn't even get in Rice University. But you do a good job for us, and you represent us well, and thank you for all you have done for our state and for education and for the Nation.

Mr. Chairman, thank you for letting me do that. I yield back.

Chairman BROOKS. Certainly, Mr. Chairman, and we also want to welcome Texas A&M to the conference of football champions, the SEC.

With that I recognize another Member from the family of the Southeastern Conference, Mr. Palazzo of Mississippi.

Mr. PALAZZO. Thank you, Mr. Chairman.

Dr. Suresh, last year the budget request for Science, Engineering, and Education for Sustainability SEES portfolio was 998 million. This year the request is 202.5 million. The fiscal year 2012 request estimated spending on SEES for fiscal year 2011 to be 660 million. The fiscal year 2013 request reflects fiscal year 2011 actual spending to be 87.96 million or 572 million less than the estimated and the previous year. I know that was a lot of numbers. Hopefully you followed.

Last year the program's mission was "to advance climate energy science engineering and education to inform the societal actions needed for environmental economic sustainability and sustainable human wellbeing." For fiscal year 2013, you described the program as having a targeted mission to "promote innovative interdisciplinary research to address pressing societal issues of clean energy and sustainability."

I do not believe "climate change" appears anywhere in the fiscal year 2013 budget request relative to the SEES portfolio. Well, I can assure you that I would be very pleased to see the Foundation make such a fiscally responsible decision by reducing requests for spending on these activities by more than half a billion dollars. I am certain this is probably not the case.

Could you please explain this drastic change for the SEES portfolio? Share with us how NSF is now capturing the funding for climate-related research.

Dr. SURESH. Thank you, Mr. Palazzo, for your question. So the SEES portfolio that was originally proposed in the fiscal year 2012 budget request to Congress, of course, was predicated upon the assumption that NSF budget for fiscal year 2012 would be $7.8 billion. It turned out, as you know, to be about $7.03 billion.

Sustainability is one of the major issues that we face as a race, human race, and sustainability has many dimensions to this. We re-baselined the SEES portfolio through very careful planning during the course of last year. In fact, the 2013 budget request entails about a $46 million increase over the 2012 current plan. And in the 2013 SEES portfolio we have a variety of activities that will involve coastal regions, the arctic coastal regions. We will have sustainable chemistry, computational and cyber-enabled mechanisms to facilitate SEES. Things like ocean acidification, rising sea levels. So whether they are explicitly or implicitly linked to a climate change

or not, these are issues that involve societal global change, and it is very important that we understand the science, engineering, and education related to sustainability.

So the re-baselined budget for SEES for 2013 is $202 million as you had indicated.

Mr. PALAZZO. I may be stepping off here. Are you familiar with the *Restore Act*? You are probably familiar with the BP Oil spill from about two years ago this April. The President or the Secretary of the Navy actually led up an effort in that regards to basically from all the pollution and penalty money, that 80 percent of that should be returned back to the Gulf states that were affected due to the oil spill, and I know that NSF, and you are talking about sustainability and things of this nature, the oceans. The Gulf of Mexico is probably one of the most overlooked bodies of water but one of the most tremendous in what it returns to our Nation in terms of oil and gas production as well as some of the best seafood in the world. I think we produce over one-third of it in the Gulf of Mexico.

Do you think that is a good thing is to take the 80 percent and push it, I mean, the Secretary of the Navy said that several reports, conservationists, environmentalists, and others would like to see this happen. I mean, you never seen people in the left and the right support a bill to return not taxpayer funds but penalty money back to the Gulf Coast region so they can begin their long-term economic and environmental recovery.

Just any thoughts on that? Have you been following it, and would you agree that that is probably a better use of the money instead of coming up here to the U.S. Treasury and disappearing?

Dr. SURESH. Well, first of all, let me say, Congressman Palazzo, that when the Gulf Oil spill took place, NSF was there immediately. In fact, we assisted, we had rapid funding mechanisms to make sure that American scientists had an opportunity to go right to the Gulf and help with their perspectives, their viewpoints, and also giving them an opportunity to gather scientific data so we can understand not only how this oil spill took place, what its implications are with respect to the coastal region, environment, and the people and people's livelihoods, but also to understand things better so that in the future if something like this were to happen anywhere else, we are much better prepared as a Nation.

We also provided resources. Our geological sciences directorate made sure that some of the key vessels and expertise were provided to the region. So NSF takes a very active part in this.

We did the same thing when the tsunami struck in Japan last year. We put in place a RAPID mechanism so that our scientists have an opportunity to understand this.

Regarding your question about how much of the money should go to restoration, I am not an expert.

Mr. PALAZZO. Unless you agree with me you don't have to make a statement for the record.

Dr. SURESH. It is way above my pay grade. So thank you.

Mr. PALAZZO. Mr. Chairman, thank you for allowing me to go over, and Dr. Suresh, thank you for the NSF's participation in studying the oil spill. I would just like to say that this is going to be—we are going to have to study this for a long, long time to find

out the true environmental consequences. So thank you for allowing me.

Chairman BROOKS. Thank you, Mr. Palazzo.

Next the Chair recognizes Mr. Harris from the great State of Maryland.

Mr. HARRIS. Thank you very much, Mr. Chairman, and thank you, Dr. Suresh and Dr. Bowen for appearing before the Subcommittee. Let me follow up a little bit with the gentleman from Mississippi here, Dr. Suresh, because I am still wondering about this SEES Program here, which is supposed to advance, "the climate and energy, science, engineering, and education to inform the societal actions needed for environmental and economic sustainability and sustainable human wellbeing."

What the heck is sustainable human wellbeing? I mean, are we afraid that America is going to, you know, disappear into some economic vacuum or—I don't get it.

Dr. SURESH. So let me give a few examples of that, what they mean by that.

Rising sea levels affecting sustainability of coastal regions and livelihoods is one example. Another example would be tsunamis, disasters. How do we prepare and what one of the components of SEES is a program that looks at a disaster as in America and what kind of science, engineering, and educational tools that we need. An agency like NSF should support that will prepare not only the scientific community but our educational enterprise to address how do we plan in the face of risk, unexpected events that take place, both natural and manmade events.

Mr. HARRIS. Well, let us take those two because I don't know—what manmade events are you talking about?

Dr. SURESH. Sustainability of urban environment, cities.

Mr. HARRIS. Okay.

Dr. SURESH. Building and cities. That is a manmade event.

Mr. HARRIS. Okay, and I am not, just not sure. I guess that just wanders a little far from science for me, but, you know, the first part of your answer I could have been hearing a NOAA hearing where they justify their climate programs.

Why should we fund multiple programs within the Federal Government that all appear in their testimony to be addressing exactly the same problem?

Dr. SURESH. At first sight seemingly they may address the same thing, but NSF is unique in multiple respects. For example, we have modeling of risk using computational and data enable science and engineering, basic science and engineering.

Mr. HARRIS. Okay. So——

Dr. SURESH. And that is——

Mr. HARRIS. Well, let me just go ahead. I only have five minutes. So then why should we fund NOAA? If NSF has all these wonderful things, why should we fund NOAA?

Dr. SURESH. We are not in the same business as NOAA. We don't do weather prediction, we don't have the National Weather Service. We collaborate with them on projects that are complimentary to one another. We are not a mission agency. Our mission is to foster basic science and engineering.

So the output of all NSF funds directly benefits NOAA and vice versa. NOAA's activities give us context and issues and problems that we can work together. So I don't think it is an overlap of activities. It is more of what one feeds into another, and NSF is upstream with NOAA.

There are other things we do. NSF funds the Antarctica Program, and we are the lead American agency to do this. We help NASA, we help NOAA, we help the U.S. Geological Survey to do their experiments there. We provide facilities there. Again, it is not an overlap. It is not wasted effort. It is not a duplication. It is a very, very complimentary effort.

Mr. HARRIS. Okay. Why, you know, I think your overall budget request is for five percent increase. Now, the other, you know, one of the other major, I would consider major science groups you compete with for money is the NIH, and my understanding is the budget was flat, level-funded for NIH.

Why should we give the NSF an increase in the time of budget stress, I will be gentle saying budget stress, when, you know, another agency that has very valuable mission, the National Institutes of Health, is not getting a five percent increase?

Dr. SURESH. So I cannot speak for other agencies. As head of NSF I can only speak for NSF. My good friend, Francis Collins, Director of NIH, can justify the needs that NIH. But I can say the following thing. NIH budget more than doubled between the late '90s and early part of the last decade. According to the *America COMPETES Act*, which was passed unanimously in the Senate, NSF budget was supposed to increase and double and obviously because of the financial situation we are in.

Mr. HARRIS. Sure. What year did that COMPETES Act pass?

Dr. SURESH. 2007.

Mr. HARRIS. What was the federal debt in 2007? Do you know, because you probably run a lot of numbers.

Dr. SURESH. Well, I know it is——

Mr. HARRIS. Was it about half of what it is now?

Dr. SURESH. Probably. Yes.

Mr. HARRIS. Okay. So you don't expect us to make decisions based on an act necessarily six years when the entire fiscal climate of the country has changed.

Dr. SURESH. Absolutely not. We are very much aware of the fact that the financial constraints at the present time forces us to make very tough choices, and one of the tough choices that we have made is——

Mr. HARRIS. Is only to have a budget increase of five percent. I have got to tell you I just—and Mr. Chairman, I am going to be done in a second. You know, America is tired of government folks coming up and saying that a budget increase of five percent is a tough choice, getting an increase of five percent. That is what the President said in his budget, that is what you are saying in your budget, and I got to tell you the American public who is out there paying 50 cents a gallon more for gas, an effective cut in their family budget, is upset at people coming in front of this Congress and saying a five percent increase in my budget is a tough choice.

I yield back the balance of my time.

Dr. SURESH. Could I provide a response to that, Mr. Chairman.

Chairman BROOKS. Thank you, Mr. Harris. Sure. The Chair will recognize Dr. Suresh to follow up.

Dr. SURESH. So when I said tough choices, I was referring to the tough choices we had to make in our priorities. So let me mention a few things, Mr. Harris, in response to your point.

NSF has the mandate not only to fund all fields of science and engineering but also supports human capital development. Since 1952, we have supported 48,000 graduate students in the country through NSF fellowships. They have been the engines of innovation in this country over the last many years. So I can only quote an example that Mr. Norm Augustine, who authored the *America COMPETES Act* mentioned. He said, if an aircraft has an overweight issue, we have to reduce weight. The first thing we don't want to throw out is the engine, and I would like to point out that NSF is the innovation engine as an agency for the country.

These are very difficult times. We are making very difficult choices in programs priorities. Our funding rate for research grant proposals is less; it is 20 percent this year. We have many, many more wonderful ideas from Americans that we are not able to fund because of the budget climate. Other time when we have competition from around the world, China's annual increase in research funding from 1996 to 2007 is 22 percent. Ours was 6.4 percent. We are the last among well-developed countries to fund this. We were even below the European Union, which has had an annual increase above the U.S. between 1996 and 2007.

So this is the context in which we have to look at the NSF budget request.

Chairman BROOKS. Mr. Harris, did you want any other follow-up response?

Mr. HARRIS. Only a comment, Mr. Chairman. The EU—you are right. The EU probably spent more. Just yesterday Greece was declared in fault. They didn't make the tough choices. I am afraid we are not making tough choices. I just—Dr. Suresh, the American public is not ready to hear that a five percent increase in a federal budget when we borrow $1.2 trillion next year, including from the Chinese, is a tough choice.

And I yield back.

Chairman BROOKS. Thank you, Mr. Harris.

The Chair next recognizes Mr. Lipinski for a second round of questions. If any other Members wish to ask a second round or participate in a second round, please let the Chair know.

Mr. LIPINSKI. Thank you, Mr. Chairman. Certainly we do have tough choices to make. I am very happy that for this, the current fiscal year that Congress did decide that NSF was—as we were cutting other things, NSF was worthy because of the important investments we make for the country, and I hope that we will again on a bipartisan basis, Congress will decide that that is the case.

I wanted to come back to advanced manufacturing, and I know in Dr. Bowen's testimony you highlight the decline in high tech manufacturing jobs in the United States. In the state that we are falling alarmingly close to being overtaken by rapidly-increasing Asian investments and knowledge and technology in intensive industries to bolster their economies.

Now, according to this year's "S&E Indicators," private businesses do 70 percent of the R&D in this country, more than two-thirds of which is done by the manufacturing sector. But just as we have seen manufacturing jobs move abroad over the last 30 years, we are now seeing the R&D sponsored by U.S. based multinationals moving overseas as well.

So both Dr. Bowen and Dr. Suresh, are there intrinsic advantages to collocating industrial R&D and manufacturing, and are you worried that this is happening and it is going to be troubling for the future of manufacturing in our country, and what could we do about that?

Dr. Bowen.

Dr. BOWEN. I will make my comments short. I think Dr. Suresh probably has the greater depth of knowledge about this.

It is very complicated. I believe, and I think the National Science Board believes that these investments that we have talked about to the extent the budget would allow it, produce a long-time underpinning of our mechanical manufacturing capability. Near term there are perhaps other issues, policy issues which could drive that.

But long term the ability for our people to have employment opportunities, have the innovation that can take place in our universities to be utilized and transferred into the economy, I think the NSF role in investment and very basic fundamental research is a key piece of it. There are other pieces for which I am perhaps not fully qualified to comment about.

Dr. SURESH. As Dr. Bowen mentioned, it is an extremely complex issue. NSF's role comes in many different ways. Fostering scientific work that leads to cutting edge tools, technologies, and processes, of course, that is one part of it.

Another part is through programs like Advanced Technological Education, which is for community colleges, two-year community colleges. Probably about 30 percent of that would have implications for advanced manufacturing. This is an area which we are focusing on. In fact, we would like to talk to other agencies to see how we can partner in new and unique ways. For example, the Department of Labor.

A third potential avenue for us is with the new proposal to have a manufacturing initiative that NIST, Department of Energy, Department of Defense, and other agencies will lead. I have had conversations with my counterpart heads of agencies about how NSF could play a role in partnership with them in providing support for activities that further the manufacturing enterprise for the country.

There are many different activities that we can focus on. One of the ideas that has come up is if other agencies, especially mission agencies and especially agencies like DOD with a lot of manufacturing base, can create an industry—university partnerships in unique ways, NSF can play a role in supporting that in innovative ways. There are ongoing discussions as recently as last week.

Mr. LIPINSKI. Is collocating an issue that if you are going to be doing your research in, if you are going to be doing your manufacturing in an area, you want to have the research there and vice versa once if the research is not going on here, that we are not

going to have the manufacturing it could lead to less manufacturing?

Dr. SURESH. I think it is very industry specific. I think it is very specific to the particular areas that we are dealing with. One recipe may not fit all, but we can look at examples of institutions and countries that are doing very well in this space.

For example, in Germany you have different mechanisms. You have tracks for science based or humanities based undergraduate education. You have a separate track for technical education, and you have industries that are collocated, you have industries that are separated, have the manufacturing in a different place.

The semiconductor industry is a good example. Even within the U.S. big companies like Qualcomm. Qualcomm doesn't do manufacturing for telephones and mobile devices. They create innovation. They have a different business model, and it is a very successful company compared to some other company in the semiconductor industry that may have manufacturing coupled to R&D activities.

So I think I am not qualified from the industry perspective, especially for multiple industries, to say which is a better model, but there are different models that work successfully.

Mr. LIPINSKI. Thank you. I see my time has expired.

I yield back. Thank you, Mr. Chairman.

Chairman BROOKS. Does any other Member wish to engage in a second round of questions?

Mr. Harris of Maryland, you are recognized.

Mr. HARRIS. Thank you very much.

Okay, Dr. Suresh. I am going to give you a chance to make up for this. What does the National—what is the National Science Foundation doing to literally help bring down the price of gas in the United States? I mean, are you partnering with DOE on, you know, geologic science to make drilling more successful, to make hydro fracturing more successful? Encourage me. Tell me there is something you all are doing that the average American who maybe is taking the time to pay attention what is going on here today says, you know what? They know what I am feeling right now, you know. Three eighty-nine a gallon gas. They understand, and this Administration is going to do something to bring down the cost of that gas.

So convince me.

Dr. SURESH. Thank you, Congressman Harris, for giving me another chance to answer the question.

Mr. HARRIS. Okay.

Dr. SURESH. I wish it were as simple as saying that NSF's work today will lead to a dollar a gallon drop in gas prices tomorrow, but unfortunately, I cannot claim that, especially as a scientist. I—we cannot do that. NSF's goal is to do cutting-edge research, and we have created programs like Innovation Corps. The idea of Innovation Corps, the SBIR Program, all these programs that NSF fosters is to take cutting-edge scientific discoveries and move them to useful products and tools that benefit society as quickly as possible.

Our mandate from Congress is still to foster basic science and engineering in all fields of science and engineering. That is the space in which we work, and if you look historically at the last 40 years, NSF has produced results that have created whole new in-

dustries. I mentioned Qualcomm earlier. The founders of Qualcomm received NSF support.

Mr. HARRIS. Dr. Suresh, I am going to ask you to stay to oil, gas, coal, something that is bringing down the cost of energy to Americans at the pump today.

Now, for instance, you know that hydro fracturing was a basic engineering, that concept is a basic engineering breakthrough. Did the NSF have anything to do with it, because I know the President has claimed somehow something the government did did something good for it. Was NSF involved?

Dr. SURESH. So NSF was involved in an entire field of study called fracture mechanics. In fact, I was a beneficiary of it. I had NSF support from 1985 to 1990, where I published about 50 papers in the area of fracture mechanics.

Mr. HARRIS. I knew you could, I knew we could see eye to eye on something. Tell me that we are doing something like that now, that we have not, in fact, neglected an entire field of energy research in search of a holy grail that we are not going to achieve. So tell me that something besides solar and wind and something going on at the NSF that is actually practical to advance our standing in the world as energy producers using the natural resources of fossil fuels that we have here in the country.

Dr. SURESH. So NSF continues to support through the engineering directorate, through the geological sciences directorate, and other programs and activities that benefit hydraulic fracturing.

Mr. HARRIS. Can you give me an example? Concrete example.

Dr. SURESH. I will be happy to——

Mr. HARRIS. If you could——

Dr. SURESH. —provide specific projects that we fund. In the area of SEES, in clean energy activities, we have programs that support novel fuel cells, wind energy, solar energy, across disciplines. So there are many, many ongoing activities at NSF that support all of this which directly and indirectly, some near term, some long term, provide opportunities to move in the direction of energy sustainability, and NSF plays a key role in this.

Mr. HARRIS. Well, let us talk a little about energy sustainability. I mean, because the sustainability word is important, and it is emotionally charged. I mean, the data I have seen is, you know, our known natural gas reserves that we can produce, not even known reserves, are over 100 years. Now, that is pretty sustainable to me.

So, again, is there an emphasis at NSF saying, okay, we are talking about sustainability, we now know that we have at least 100 years of natural gas that we could unlock. We do have technical difficulties. I will admit. I mean, you know, the hydro fracturing technique is good. Every one of these techniques can get better.

Again, is there an emphasis at the NSF or is this part or is the NSF engaging in the, what seems to be an Administration-wide effort to put our resources into every other single source of energy except fossil fuel, or has the NSF like the NIH kind of stepped back and say, we are not letting politics play. This is science. This is not politics, because I will tell you, Doctor, I am kind of disappointed that you roll out solar stuff and fuel cell, this fuel cell, and you can't give me a concrete example of a single project that NSF is

funding right now that will make it easier, safer, better, cheaper to deliver fossil fuel to the American consumer like gasoline.

Dr. SURESH. So we have projects in our materials division, division of materials research, for example, that look at new materials for drilling. That project has been funded for many years through a variety of programs. That is an example.

Mr. HARRIS. I knew we would see eye to eye eventually. If you could get me that, I would appreciate that, and I yield back my time.

Dr. SURESH. I will be happy to give you a lot more examples.

Mr. HARRIS. Thank you very, very much.

Chairman BROOKS. Any other Members who wish to go through a second round of questions?

Seeing none, I thank the witnesses for their valuable testimony and the Members for their questions. It has been a very lively and informative discussion.

The members of the Subcommittee may have additional questions for the witnesses, and we will ask you to respond to those in writing. The record will remain open for two weeks for additional comments from members. The witnesses are excused, and this hearing is adjourned.

[Whereupon, at 11:28 a.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Subra Suresh, Director, National Science Foundation

UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION
Hearing on
An Overview of the National Science Foundation Budget for Fiscal Year 2013

February 28, 2012

Dr. Subra Suresh,
Director
National Science Foundation

Questions for the Record Submitted by
Mo Brooks

Question 1. In your testimony you stated that, "NSF provides a much-needed bridge between research and discovery that would otherwise be neglected and remain untapped by the commercial marketplace." Can you describe this role and explain how it exists within the Foundation's primary mission of support for basic research?

Answer: The National Science Foundation supports fundamental research and education in science and engineering across the board. Additionally, programs within the National Science Foundation help to foster and encourage the translation of new knowledge generated through basic research into processes, products and methodologies with significant economic or societal impact.

NSF has developed a strategy utilizing a combination of the Foundation's experience, existing programs, and new initiatives to speed the generation of useful discoveries and their effective penetration into industry. By so doing, these discoveries can yield high-value products and processes, new businesses and even new industries, greatly expanded employment opportunities, and a more technologically advanced workforce widely distributed across the U.S.

Long-standing programs which enhance the commercialization potential of the fruits of our basic research investments include, but are not limited to:

- **Engineering Research Centers (ERCs)**—Established in 1985, this is the flagship engineering centers program at NSF. The 58 ERCs formed to date have literally changed the culture of academic engineering by supporting interdisciplinary teams and infrastructure that strategically join discovery with research that advances enabling systems technology, in partnership with industry.

- **Industry/University Cooperative Research Centers (I/UCRCs)**—Formed in 1972, the I/UCRC program is one of the oldest programs at NSF. It has endured because it is a model that works: multiple interdisciplinary teams of faculty and students focusing on a portfolio of industry-relevant and mutually agreed-upon research. Industry and other agencies provide the majority of the support—seven to eight times the NSF investment.

- **Partnerships for Innovation (PFI)**—Begun in 2000, the PFI program promotes collaborations to stimulate the translation and transfer of knowledge created by the research enterprise into innovations that create new wealth and build strong local, regional, and

national economies. PFI is an umbrella for two sub-programs, one early stage, the other late stage, along the spectrum of innovation activities.

- **Grant Opportunities for Academic Liaison with Industry (GOALI)**—This investment, begun in 1994, promotes university–industry collaboration by supporting academic fellowships/traineeships in industry, industrial practitioners on campus, and industry–university team research.

- **Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR)**—This investment, begun in 1982, stimulates technological innovation by strengthening the role of small business in meeting federal R&D needs, increasing the commercial application of federally supported research results, and fostering participation by socially and economically disadvantaged and women-owned small businesses.

- **Innovation Corps (I-Corps)**—The NSF I-Corps program, established in 2011, provides a framework to assess the readiness of emerging technology concepts for transitioning into valuable new products through a public–private partnership. I-Corps brings together the technological, entrepreneurial, and business know-how to support the translation of research ripe for innovation out of academic labs.

Question 2. Please explain the role private industry plays, in terms of creating and retaining science and engineering jobs, versus those types of positions funded with federal dollars? How do we ensure the science and engineering workforce continues to grow, perhaps better focusing this responsibility on the private sector?

Answer: The federal government, universities, and the private sector play complementary roles in creating and retaining science and engineering jobs. The difference lies in whether the focus is on basic or applied research. Basic research jobs have the potential to generate new knowledge with large benefits for the national economy. A large portion of this work — two-thirds of basic research in 2009 — is performed by universities and nonprofit organizations.[1] Private for-profit firms are reluctant to invest in jobs that create these kinds of knowledge out of concern that competitors will reap much of the benefit from their investments. In contrast, private firms support the bulk of applied science and engineering (S&E) jobs to conduct those research and development activities that are targeted to bringing new products and services to market. The most recent NSF data indicate that about two-thirds of workers in S&E occupations work in for-profit settings, one-fifth in education or non-profits, and one-eighth in government.[1]

To ensure that the S&E workforce continues to grow, it is vital that the market for both basic and applied research jobs continues to grow as well. Increasingly, partnerships between public and private entities are helping both aspects of research to develop. For example, NSF has a number of specific programs that partner basic research and companies to develop downstream applications to help bridge the so-called "valley of death," such as the I-Corps program and the Small Business Innovation Research (SBIR) program.

Question 3. The stated goal of the new OneNSF Framework is to "enable seamless operations across organizational and disciplinary boundaries." What was the impetus for putting this Framework in place? Will it make the Foundation more efficient or eliminate

[1] National Science Board. 2012. *Science and Engineering Indicators 2012*. Arlington VA: National Science Foundation (NSB 12-01).

duplication across the directorates? Why is it important to undertake today? Has the Foundation had problems with operations that require this type of initiative?

Answer: The OneNSF approach builds on the foundation's mission to support fundamental research and education. It seeks to empower NSF to respond to new challenges in a changing global environment, leverage resources and opportunities for maximum impact, and provide leadership to establish innovative practices, programs, and paradigms that advance scientific knowledge and science, technology, engineering, and mathematics (STEM) education. These capabilities — responsiveness, leverage, and leadership — are the core characteristics of OneNSF.

Within the foundation, OneNSF identifies policies, strategies, and practices to foster and sustain a culture and workplace environment based on cooperation and communication across organizational divisions and disciplinary boundaries.

Externally, OneNSF encourages a heightened level of cooperation and consensus between NSF and its partners, and among NSF grantees and their collaborators in the science and engineering community around the globe. This follows the principle that "good science anywhere is good for science everywhere."

Question 4. The SEES initiative is the second largest priority in the OneNSF Framework at $202.5 million and the Clean Energy investment seems to be the largest single investment highlighted in the NSF portfolio at $355.4 million. While I understand the Foundation is increasing its investments in cyber-related activities and multi-disciplinary activities, too, I remain concerned that energy-related portfolios continue to grow at disproportionate rates. I am concerned that this emphasis may be at the expense of other potentially transformative research. How can we ensure that is not the case? The goal of NSF is to support basic research across disciplines, so the question becomes are the SEES and clean energy priorities funded here also funded and conducted by agencies like the Department of Energy? How are you ensuring this is not duplicative work?

Answer: Science, Engineering, and Education for Sustainability (SEES) and many other NSF priority areas are specifically designed to enable advancements in not only traditional disciplinary topics, but to encourage exploration and understanding in areas outside or between those disciplines. For example, the Sustainable Energy Pathways (SEP) component of NSF's SEES activity is targeted at interdisciplinary basic research in science, engineering, and education by teams of researchers comprised of at least three lead investigators who represent at least two scientific disciplines on each proposal. This approach brings expertise from traditional disciplines to collaborate on questions that require multidisciplinary tactics to successfully solve — ultimately enabling new disciplinary knowledge to emerge. Many of NSF's clean energy investments have similar multidisciplinary foundations, such as Research at the Interface of the Biological, Mathematical, and Physical Sciences (BIOMaPS), which brings together biology, mathematical and physical sciences, and engineering to accelerate understanding of biological systems and translate that knowledge into new technologies.

The issue of possible duplication of effort across agencies is important to NSF and receives considerable attention. NSF has a unique role in the inter-agency sustainability arena because of its unique involvement with all areas of science, engineering, and education that are required to address the complex system level problems of sustainability. In addition, NSF-supported research typically precedes direct application by mission agencies or others by years to decades.

NSF also takes additional steps to ensure that our efforts leverage – not duplicate – other federal investments. Our activities in the sustainability arena are developed in close consultation with the Department of Energy (DOE), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), the United States Department of Agriculture (USDA), and other federal agencies. In addition, NSF has established partnerships with these agencies to maximize efforts and funding and minimize overlap. For example, there are several formal collaborations between DOE and NSF on programs that involve clean energy engineering, science, social science, economics and human behavioral aspects associated with disruptive changes in energy strategies. These include such projects as jointly funded Engineering Research Centers; the Foundational Program to Advance Cell Efficiency with DOE's Energy Efficiency and Renewable Energy (EERE) SunShot program; and a DOE thermoelectrics program.

Question 5. NSF has been identified as the "only federal agency dedicated to the support of basic research and education in all fields of science and engineering." Do you believe that some of the more applied areas of research identified in the America COMPETES Reauthorization Act, coupled with multiple Administration applied priorities for NSF in the FY13 budget request dilutes the funding for basic, fundamental research? Please explain your response.

Answer: As noted, NSF's mission is to support the full breadth of science and engineering research and education. We are constantly alert to emerging ideas with the potential to transform the world, establish new paradigms, and even foster new industries. NSF has helped to make the U.S. the undisputed world leader in science, technology, and innovation.

The results of frontier research have a long record of improving lives and meeting national needs. They are the very bedrock of economic growth; the path to energy, agricultural, and environmental sustainability; the seeds of the next technology revolution; and the foundation for advances in medicine. Sustained momentum in NSF's core programs is essential for progress in science and engineering. The broad scope of NSF puts us in a unique position to integrate the natural sciences and engineering with the social, behavioral, and economic sciences to address the complex societal challenges of today. For all these reasons, the 2013 budget provides increased support for the core fundamental research programs across NSF by five percent. This core research, which constitutes the largest share of NSF expenditures, lays the foundation for progress in science and technology and enhances our ability to address emerging challenges.

NSF investments in research and education have returned exceptional dividends to the American people. To keep those benefits flowing, we need to constantly replenish the wellspring of new ideas and train new talent while serving as good stewards of the public trust. That is the fundamental and continuing mission of NSF. With global competition for knowledge and talent reaching a red-hot pitch, we must focus our attention on finding the sophisticated solutions that will ensure a prosperous, secure, and healthy future for the Nation and the world.

Question 6. The FY13 budget request also calls for fundamentally reframing the Education and Human Resources investment portfolio into three categories: Core R&D, Leadership, and Expeditions. As part of the Core R&D investments, the request includes $20 million for a new "Core Launch Fund" or $5 million for each of four core divisions: STEM learning; STEM learning environments; broadening participation and institutional capacity in STEM; and STEM professional workforce preparation. Please expand on the

need for this new money, how it will be spent, what research you hope to fund that is not already being funded, and what you hope to achieve that could not be achieved with current funding solicitations?

Answer: The core launch funds are needed because, as a leader in research in fundamental science and education, NSF intends to initiate a more systematic and long-term approach to STEM education research and development (R&D). This is consistent with the way in which the rest of NSF supports discovery, through core disciplinary funding within the Research and Related Activities (R&RA) directorates, enabling researchers to pursue questions in the areas fundamental to advancing knowledge. The FY 2013 budget proposal seeks to ground the programs in the NSF Education and Human Resources (EHR) directorate, and other NSF education investments, on a more solid R&D base; this represents a first step in a longer term process of aligning individual programs within a coherent conceptual framework. This incremental strategy enables the directorate to respond to recommendations contained in many national STEM education reports[2] for needed future research and to address the relative under-funding of STEM education research. Although R&D is essential to strategic government investments in education, CoSTEM reports that currently only about 15 percent of the entire government investment in STEM education is dedicated to research on the education and learning process itself. This relatively low investment in research deprives the education enterprise of opportunities to understand systematically, and over the long term, what is being learned as a result of current investments and to put that learning to use as an evidence base from which to make future strategic decisions.

In FY 2013, a total of $20 million is allocated to the EHR R&D core with each division receiving $5 million to invest in key areas or pilot work to launch transformational and innovative investigations in one of the four specified areas. The types of new activities that the Foundation expects to fund will be grant awards through merit review to principal investigators to:

- Document what is known about STEM learning to date;
- Develop plans for coordination and synthesis among STEM learning research and development programs;
- Identify critical grand challenges and initiate calls for research and development in focused need areas;
- Document what is known about STEM learning environments that show promise for improving student learning and/or retention of all students, particularly those underrepresented in STEM disciplines, both inside and outside of schools;
- Develop plans for networking and coordination among STEM learning environment R&D programs that will allow synthesis of knowledge and identification of key challenges;
- Document what is known about building and expanding a coherent body of knowledge about successful approaches and models for broadening STEM participation and building institutional capacity; and

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[2] *Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report* (National Science and Technology Council, February 2012); *The Federal Science, Technology, Engineering, and Mathematics (STEM) Education Portfolio* (National Science and Technology Council, December 2011); *Science Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs Across Multiple Agencies* (Government Accountability Office, January 2012); *Learning Science In Informal Environments: People, Places, and Pursuits* (2009); *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics* (2011); and *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* (2011).

- Document what is known about STEM professional workforce preparation and develop plans for coordination and synthesis among NSF STEM workforce development programs.

This coordinated R&D approach, which is expected to transcend the boundaries of the individual divisions leading the respective areas, will begin to create and synthesize the knowledge base of rigorous and relevant research essential to improvement based on a range of contextual factors. We emphasize that this approach is research and development in education in order to advance knowledge; it is essential in order to design and implement models and activities that will pursue research questions in contexts that vary in terms of learners, capacity, resources, etc. This core effort will complement EHR solicitations that are driven by education levels or learning contexts and focus on capacity building, pilots, and small-scale implementation.

Traditional approaches leave relatively limited resources for STEM education research. Thus, projects funded through existing solicitations do not always allow for both foundational and frontier education and learning research that will transform STEM teaching and learning for the twenty-first century. The directorate expects to situate its programs within broad research frameworks that will allow NSF to use the results of specific, focused projects to build an evidence base of wider significance that will inform future efforts. For example, the recent NRC report on *Successful K-12 STEM Education* enumerated three broadly shared goals for STEM education in the U.S.:

- Expand the number of STEM degrees and careers and broaden participation of underrepresented groups;
- Expand the STEM-capable workforce and the participation of underrepresented groups; and
- Increase STEM literacy for all students.

However, the study concluded that "Scientific research provides little evidence about how to accomplish the three broad goals...[and] is even limited with respect to intermediate goals" (p. 5) The core launch funds are designed to help NSF begin to develop strategies for responding to challenges such as these.

Question 7. The federal government has been funding STEM education for decades. Just over the past five years alone, we have spent over $16 billion on the issue. Every year, a larger emphasis is placed on the subject; and every year, we hear how we are falling further behind. What do we, as a Nation, have to show for all of the time, effort, and American taxpayer dollars that have already been devoted to this issue? What kind of return are we getting on our investment? How can we be confident that we are putting this money in the right place and on the right activities?

Answer: Student test scores present a mixed picture of achievement according to information summarized and presented by NSF's *Science and Engineering Indicators* (2012).[3] Scores on the National Assessment of Educational Progress (NAEP) mathematics test increased among younger students (fourth graders and eighth graders) between 1990 and 2007. Between 2007 and 2009, average mathematics scores leveled off for grade 4 and continued to improve for grade 8. Among 12th graders, average mathematics scores showed a gain from 2005 to 2009.[3] These improvements in performance were generally shared by boys and girls and across racial, ethnic, and economic groups. Black students narrowed gaps with white students that were first

[3] Science and Engineering Indicators: 2012, Chapter 1. Elementary and Secondary Mathematics and Science Education. http://www.nsf.gov/statistics/seind12/c1/c1h.htm

observed in 1973. However, score gaps among demographic groups remained substantial. Similar gains were also seen in the 2007 Trends in International Mathematics and Science Study (TIMSS) in mathematics but not in science. However, on the 2006 Program for International Student Assessment (PISA), U.S. 15-year-olds scored below most selected nations and the U.S. dropped below its rank in 2000 in both mathematics and science. Although U.S. PISA scores in both mathematics and science rose between 2006 and 2009, they remained below the scores of most economically advanced countries in the OECD.

National and state education policies focus on improving learning by U.S. students. National policy goals include increasing student achievement over all, reducing disparities in performance among key subgroups of students, moving the international ranking of U.S. students from the middle to the top over the next decade, and regaining U.S. leadership in STEM education. NSF's investments in STEM education fields reflect strong support for the R&D elements of recent reform efforts, including studying common core state standards in mathematics, strengthening curricula, promoting advanced course taking, enhancing teacher quality, and expanding technology in education to address student performance.

As discussed in Chapter 1 of *Science and Engineering Indicators* (2012),[4] progress has been mixed, varies among regions and school districts, and differs between middle and high school. The percentage of public middle and high school science and mathematics teachers with advanced degrees and full certification has increased since 2003. However, science teachers in high poverty schools were less likely to have advanced degrees than science teachers in low-poverty schools. New teachers found in high-poverty or high-minority schools were also more likely to have been hired through an alternative certification program. In-field[5] teaching in science and mathematics was less prevalent at lower than at higher grade levels, but most high school teachers of mathematics and science taught in field. Based on 2007 data reported in *Indicators 2012,* 88 percent of high school teachers in mathematics, and 93 percent of high school teachers in biology/life sciences taught in field.

Patterns are clearly nuanced and progress has been slower than hoped; however, NSF believes that its STEM education scholarship, fellowship, and trainee activities have contributed to gains where they have occurred. Through its funding for these leadership activities, NSF will continue to invest in teacher education because of the crucial connections between teachers and student performance. For example, between fiscal years 2002 and 2011, NSF's NOYCE awards are estimated to produce approximately 10,000 new science and mathematics teachers, and 430 master science and mathematics teachers for the Nation's high-needs school districts. On the workforce side, since the inception of the twenty-year old Louis Stokes Alliances for Minority Participation (LSAMP) program, nearly 400,000 STEM baccalaureate degrees have been awarded to underrepresented minority students. Since the creation of the Integrative Graduate Education and Research Traineeship (IGERT) program, approximately 1,500 students have graduated from IGERT Ph.D. programs.

In addition to its investments in workforce development (including teacher preparation), NSF believes its emphasis on research and development in STEM education will help to address concerns about whether investments are going to the right activities. For example, programs that have traditionally focused almost exclusively on capacity building, such as HBCU-UP and

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[4] Science and Engineering Indicators: 2012, Chapter 1. Elementary and Secondary Mathematics and Science Education. http://www.nsf.gov/statistics/seind12/c1/c1h.htm#s3

[5] "In-field" teaching is the most rigorous level and means that the teacher had a degree or full certification in the subject matter taught.

other programs in the Division for Human Resource Development (HRD), are adding a strand on Broadening Participation Research, which will provide support to research projects that seek to create and study new theory-driven models and innovations related to the participation and success of diverse groups in STEM undergraduate education. Thus, NSF funding will be helping to develop the knowledge base in this area while continuing to directly support institutions as they improve their quality of education.

Question 8. Since the beginning of 2012 both the Office of Science and Technology Policy (OSTP) and the GAO have issued reports on the number of STEM programs in existence across the federal government. Both reports found over 200 federal STEM programs (252 from OSTP and 209 from GAO) totaling over $3 billion dollars. What is NSF doing to ensure the NSF's contribution is of the highest caliber basic research on STEM education? While the reports did not find direct duplication they did find overlap in much of these programs. How can we ensure federal dollars are being spent wisely and NSF investments are not duplicative of those at NASA, DOE or other federal agencies?

Answer: The legislation creating NSF (Public Law 81-507) sets forth the mandate "to promote the progress of science," which the Foundation's strategic plan describes as "advancing research and education in S&E [science and engineering] across all fields and disciplines and at all educational levels."[6] NSF is unique among agencies in that it supports basic research in all fields of science, engineering and STEM education, and NSF is thus distinguished among other agencies in its access to cutting-edge science and engineering research in all STEM fields on which it can draw to develop its R&D education programs; this relationship also provides an opportunity to influence the educational components of substantial investments in basic scientific research. To ensure that the highest caliber basic research on STEM education is funded, NSF uses competitive merit review and focuses on national priorities. Additionally, NSF uses periodic reviews and evaluations of programs to shape program and portfolio directions and emphases.

NSF leaders play critical roles on the NSTC Committee on STEM (CoSTEM): NSF Director Dr. Subra Suresh co-chairs the CoSTEM along with Dr. Carl Wieman of OSTP, and Dr. Joan Ferrini-Mundy, the Assistant Director for Education and Human Resources (EHR), co-chairs the CoSTEM Strategic Plan Task Group. The inventory of STEM education funding conducted by CoSTEM last year found that NSF and the Department of Education (ED) are by far the largest contributors to the federal STEM education enterprise, with EHR providing the bulk of the NSF funding. To ensure that federal investments are managed wisely, NSF will continue to work with CoSTEM as it develops a five-year strategic plan for federal investment in STEM to be released later this spring. This strategic plan will allow for increased coordination of STEM education programs across the federal agencies and promote more focused efforts to address national priorities in STEM education. The Government Accountability Office (GAO) in its 2012 report *Science Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs across Multiple Agencies*, states that 83 percent of programs overlap with at least one other program. However, the GAO cautions that "even when programs overlap, the services they provide and the populations they serve may differ in meaningful ways" (pp.i) andthat this finding calls for attention to coordination and strategic planning. A more refined inventory by the National Science and Technology Council (NSTC),[7]

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[6] *Empowering the National Through discovery and Innovation; NSF Strategic Plan for Fiscal years (FY) 2011-2016*, p.3

[7] *Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report* (National Science and Technology Council, February 2012); *The Federal*

which employed the GAO definitions in a more granular analysis of programs, concluded there was "only modest overlap in investments and no duplication among the STEM education investments, as defined by GAO" (p. xiii). The studies agree, however, that there are opportunities for alignment and coordination.

In addition to the government-wide CoSTEM activity, NSF is also developing partnerships with other agencies on a one-to-one basis. For example, the 2013 Budget Request includes a joint K-16 mathematics initiative with ED, and both agencies are also working together to better coordinate their Mathematics and Science Partnership (MSP) activities.

Questions for the Record Submitted by
Eddie Bernice Johnson

QUESTIONS FOR DR. SURESH

1. It appears that every one of the programs designed to broaden participation in STEM is being held flat even as other STEM programs grow and new ones are created. Part of NSF's mission is to be broadly inclusive, as stated in the agency's strategic plan. I think you've done that pretty well, and probably better than any other agency. But we have not actually moved the needle much in terms of participation in STEM by underrepresented groups nationwide. Given the low participation by these groups in most STEM disciplines, the changing demographics of this country are going to catch up with us very soon with respect to having a STEM-skilled workforce for 21st Century jobs. In some industries we are already seeing a troubling skills gap that will only become worse if we don't broaden participation in STEM by minorities, and women for that matter.

Question a. How do you justify continuing to hold the budgets flat for these relatively small programs when broadening participation is becoming not just a moral imperative but an economic one as well?

Answer: NSF's commitment to broadening the participation of underrepresented minorities, women and girls, and persons with disabilities (through the multiple mechanisms, programs, and approaches available to the agency) has not wavered. It is based on both the moral imperative and the essential place of diversity in achieving innovation and solving global problems in science. Furthermore, it is based on the assumptions that intellectual diversity of thought and diversity in the composition of participants strengthen the STEM enterprise.

The NSF FY 2013 Budget Request reflects this commitment by sustaining the funding levels in key broadening participation programs, seeking strategic leveraging, and introducing new investment priorities. For instance, the budget request for the Directorate for Education and Human Resources (EHR) includes $5.0 million of new resources to be directed toward launching a core research and development effort in broadening participation and institutional capacity.

For leveraging, there are efforts underway in EHR to ensure renewed and stronger attention to broadening participation in several of its development and implementation programs in the Division of Undergraduate Education (e.g., Advanced Technological Education, NOYCE, and

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Science, Technology, Engineering, and Mathematics (STEM) Education Portfolio (National Science and Technology Council, December 2011).

STEP) by building on the best practices and effective models that have been funded through programs in the Division of Human Resources Development (e.g., HBCU-UP and TCUP). In addition, several directorates and offices funded by the Research and Related Activities account leverage existing discipline-specific efforts to broaden participation through emphases in key programs. These include Computing Education for the 21st Century (CE21) in the Directorate for Computer and Information Sciences (CISE) and Engineering and the Broadening Participation Research Initiation Grants in Engineering (BRIGE) program in the Directorate for Engineering (ENG).

In order to address issues of retention of broadly diverse student cohorts in the STEM fields, NSF is focusing efforts on more fully engaging community colleges in bridging to the baccalaureate in addition to their efforts in technical workforce development. Further, as part of *OneNSF* activities, EHR is leading the design of the new Widening Implementation and Demonstration of Evidence-based Reforms (WIDER) program which emphasizes broadening participation in the context of pedagogical practice at universities and colleges. And, the new Career Life Balance Initiative is an *OneNSF* initiative that exemplifies the Foundation's commitment to broadening the participation of women in the science and engineering academic workforce.

Questions for the Record Submitted by
Daniel Lipinski

QUESTIONS FOR DR. SURESH

Question 1. The budget request proposes a 23 percent increase in the Graduate Research Fellowship Program's budget. The focus of this increase is to raise the student stipend for fellows to $32,000 annually. This reflects more than a 100% increase in the size of stipends since 1999 – almost 3-times the rate of inflation. Among comparable fellowship programs, GRF stipends already rate among the highest. Why is it better to use these funds to increase stipend sizes rather than funding an additional 100 fellows next year?

Answer: Graduate education plays a critical role in the preparation of the S&E workforce in the United States. Scientists and engineers with advanced degrees contribute to society through their discoveries and research innovations that impact our Nation's well-being and economic future. Through its program of providing individual fellowships to the most promising applicants, the Graduate Research Fellowship (GRF) program has had a distinguished and vital role in supporting the researchers and the teachers of the future since 1952. Fellowship support prepares students for a broad range of disciplinary and interdisciplinary careers. Although other fellowship programs have developed and grown, GRF remains the largest program, reaching all fields of science supported by NSF. Numerous reports conclude that increasing the number and value of Graduate Research Fellowships will attract more Americans, including women and minorities, into science and engineering.[8,9] Similarly, failure to keep pace with economic demands will deter talented Americans from pursuing STEM careers.

[8] Richard B. Freeman, Tanwin Chang and Hanley Chiang, 2009. "Supporting 'The Best and Brightest' in Science and Engineering: NSF Graduate Research Fellowships," NBER Chapters, in: Science and Engineering Careers in the United States: An Analysis of Markets and Employment, pages 19-57 National Bureau of Economic Research, Inc. (http:www.nber.org/papers/w11623). Note: This work was supported by NSF.

As proposed in the FY 2013 Budget Request, 2,000 new fellowships will be awarded maintaining the doubling of new fellowship awards achieved in FY 2010. The increase in the GRF budget reflects an increase in the stipend and the higher cost of education allowance (increased from $10,500 to $12,000 in FY 2012), coupled with a larger number of continuing fellows and 2,000 new fellowship awards per year. The cost of education allowance of $12,000 is directed by Congress in the America COMPETES Reauthorization Act of 2010 (P.L. 111-358, Sec 510(d)).

The GRFP annual stipend has been stable at $30,000 since FY 2004. The stipend was maintained at $15,000 from FY 1997 through FY 1999. The stipend was then increased stepwise beginning in FY 2000 ($16,800) to $30,000 in FY 2004, where it has remained. The proposed $32,000 stipend in FY 2013 is a 6.7 percent increase in the annual stipend over the FY 2004 level. This is a modest increase compared to increases in cost of both education[10],[11] and living since the size of this stipend was established almost a decade ago. Specifically, the cost of living has substantially outpaced the value of the stipend. According to the U.S. Department of Labor's Consumer Price Index (CPI) inflation calculator, the GRF stipend level ($30,000) established in FY 2004 has not kept pace with the cost-of-living. Using the CPI inflation calculator, a $30,000 stipend in FY 2004 corresponds to $36,450 in FY 2012 (using FY 2004 and $30,000 as the base year and amount, respectively).[10]

Analysis of GRF historical data finds:

- The average measured academic skill (e.g., GPA, GRE) of awardees rises with the value of fellowships.[8]

- It is estimated that for every 10 percent increase in the stipend value, the number of applications goes up by 8 to 10 percent.[8]

- GRF fellow perception of the adequacy of the stipend level has declined since FY 2004. In the annual survey of GRF fellows, students were asked how their stipend level compared to stipends received by research assistants or teaching assistants. Fellows could respond either a) did not meet expectations, b) met expectations, or c) exceeded expectations. There has been a steady decrease in the percentage of fellows reporting that the stipend cost "exceeded expectations". For example, 88 percent reported the stipend level exceeded their expectations in FY 2004, while only 68 percent did so in FY 2011, the most recent year for which data are available.

2. NSF is proposing a 22 percent cut to the informal STEM education program even as the overall Education and Human Resources budget grows. This cut is coming at the same time that science agencies across the government -agencies like NASA and NOAA that primarily engage in informal, experiential learning-are also seeing big cuts to their STEM education budgets.

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[9] The 2007 report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* recommends "up to $20,000 annually for tuition and fees" for a graduate fellowship program. The National Academies Press, 2007.

[10] Published Inflation Conversion Factors by Dr. Robert C. Sahr, Oregon State University, 2007 http://oregonstate.edu/cla/polisci/faculty-research/sahr/infcf16652007.pdf

[11] NSB Science and Engineering Indicators 2012: p. 2-11: Higher Education Price Index rose 0.9% in FY2010.

Question a. How do you justify this cut in an otherwise growing budget? If informal providers such as museums and public television can't turn to NSF for support, where do you recommend they turn?

Answer: NSF remains committed to supporting informal science education and will continue to provide opportunities for the field to access funding via the Advancing Informal STEM Learning program (AISL), formerly named Informal Science Education (ISE). AISL is designed to emphasize NSF's contributions to scientific research and public science literacy while also highlighting future program priorities which are to:

- Advance the field;
- Promote innovation at the frontiers of informal learning;
- Broaden participation; and
- Foster effective project collaborations.

A fraction of the 22 percent cut to the AISL program is due to the termination of the Connecting Research to Public Audiences (CRPA) activity in FY 2013 (-$4.0 million). While it is true that the proposed overall reduction for AISL comes at a time when other federal agencies are experiencing similar reductions in funding, we will use this as an opportunity to strengthen our focus on research to ensure that future investments have a lasting impact by increasing our understanding of what works, why, and for whom in informal learning environments. NSF is expanding efforts to ensure that education research and development, including those efforts aimed at informal science education, are widely integrated in all research activities across the agency. Consequently, research support for informal science activities will continue at NSF through AISL, other programs and activities (e.g. Discovery Research K-12 (DR-K12)) in the Division of Research on Learning in Formal and Informal Settings (DRL), and in coordination with the Research and Related (R&RA) directorates and offices.

AISL will continue to support research activities that build the knowledge base in the field. Additional basic research activities on informal education will be supported by the Research on Education and Learning (REAL) program. Similarly, projects that have a significant K-12 component will be supported by the DR-K12 program and researchers in those areas will be directed to DR-K12, as it becomes increasingly clear that continuity across learning environments is necessary to support effective student learning. Finally, EHR will partner with other NSF directorates to support appropriate informal science research activities that complement and strengthen existing activities in the NSF research centers.

EHR will also look for opportunities to collaborate with other federal agencies that are investing in advancing informal STEM learning. We expect to have a clearer picture of the federal-wide activity in informal education when the CoSTEM strategic plan is completed.

Question b. Also, I worry this cut could diminish NSF's opportunities for branding, which increases public recognition and support for the agency and your mission. Can you comment on that aspect of it too?

Answer: NSF branding is not an explicit goal of the AISL, formerly the ISE program, although it is likely that some efforts funded through this program recognize NSF funding in explicit ways that bring visibility for the agency to parts of the public. In addition, all grants funded by NSF are expected to acknowledge the source of support. In FY 2013, EHR will examine its portfolio of activities in contexts outside of school settings so that the directorate is better positioned to

support research in understanding why and in what context informal science education activities are effective mechanisms to foster the following:

i. Ongoing engagement and understanding in STEM;
ii. Ways that learners may come to see themselves as STEM learners; and
iii. Continuity across learning environments.

Increased emphasis on collaborative funding with DRL and the other NSF directorates will ensure that NSF remains a prominent funder of high quality informal science education and that the portfolio is enriched by research-based models and projects that inform a broader range of educational and scientific professional communities. This will help with NSF visibility in a number of arenas. To further support this effort, NSF will seek to establish a common set of evidentiary standards for programs and activities across the agency that fund public understanding and communication of science and engineering activities as part of the agency's 2012/2013 Performance Plan. Finally, with new leadership in NSF's Office of Legislative and Public Affairs (OLPA), new collaborations are underway between EHR and OLPA to address mutual interests in the public understanding and the communication of science. The topic of public recognition for NSF is a component of both of these efforts.

Question 3: NSF launched the agency-wide interdisciplinary program called INSPIRE just last year, and you are proposing to increase it by 200 percent in FY 2013. Can you please discuss what the INSPIRE program has achieved so far, and any lessons learned that you will apply to the next round of grants?

Answer: INSPIRE was established to address some of the most complicated and pressing scientific problems that lie at the intersections of traditional disciplines and to advance the NSF's strategic goal of *Transform the Frontiers*. INSPIRE will strengthen NSF's support of interdisciplinary, potentially transformative research by complementing existing efforts with a suite of new, highly innovative Foundation-wide activities and funding opportunities. The first of these, the pilot CREATIV (Creative Research Awards for Transformative Interdisciplinary Ventures) funding mechanism, was launched in FY 2012, with a maximum award size of $1.0 million. All FY 2012 INSPIRE funds will be used to support CREATIV awards. The budget request for FY 2013 is intended to continue support for CREATIV at a similar level to FY 2012 and to establish a second pilot funding mechanism for larger "mid-scale" awards up to the range of $2.50 million to $3.0 million.

CREATIV was announced in November 2011. To encourage bold high-risk interdisciplinary projects, CREATIV offers principal investigators (PIs) a means of requesting substantial funding for any NSF-supported topic through a special process based primarily on rigorous internal review by expert NSF program officers (POs). As of March 27, 2012, over 170 formal inquiries from potential PIs have been received, ten of which have been authorized by interdisciplinary teams of POs for submission of full proposals; the rate and quality of inquiries is increasing as the research community becomes more familiar with the CREATIV opportunity and with its review criteria. NSF-wide Integrative Activities (IA) co-funding encourages POs to invest their program funds in these potentially transformative interdisciplinary projects. The first set of CREATIV awards is expected to be announced in the late spring of 2012.

With regard to lessons learned, the internal process for organizing teams of POs to handle CREATIV inquiries is currently being streamlined, based on the experience of the first few months. Also, POs have found most inquiries from PIs to be less appropriate for the special CREATIV process than for normal external review through regular programs. These initial

challenges were expected. The submission and review process for the second "mid-scale" pilot is under development, benefiting from the lessons of CREATIV. An important aspect of INSPIRE are evaluation activities that will provide opportunities for further improvement and impact assessment.

Responses by Ray Bowen, Chairman, National Science Board

Questions for the Record
The Honorable Mo Brooks

House Committee on Science, Space, and Technology
Subcommittee on Research and Science Education

An Overview of the National Science Foundation Budget for Fiscal Year 2013

Tuesday, February 28, 2012
10:00 A.M.

Questions for Dr. Bowen:

Question 1: The FY 13 Budget Request for the OneNSF Framework is $807 million or 11 percent of the entire NSF budget. What role did the Board play in the formation of this Framework and were you consulted on the priorities to include in it?

Answer: The Board was thoroughly engaged in the development of the agency's FY 13 Budget Request, including the OneNSF initiative. The Board's involvement in the budget formulation process occurs primarily through its Committee on Strategy and Budget, which works closely with NSF senior leadership throughout the year. The Board is involved with and kept apprised of the development of the budget every step of the way — from the initial planning stage through final approval of the submission to the Office of Management and Budget.

The NSF FY 2013 Budget Request is built on an understanding that investments in science and technology are essential to America's long-term economic growth. Continued Federal support for research and education across science and engineering fields is critical, particularly in our current economic environment. This is especially true given that private firms have decreased their investments in long-term research and development projects.

The Board is especially supportive of those programs that improve operations across organizational and disciplinary boundaries and use scarce resources effectively. We feel that the OneNSF Framework will unify the Foundation's efforts to solve some of our critical educational, scientific, and engineering challenges by ensuring NSF program officers have the ability to enable cross-cutting collaboration.

The Board feels the priorities contained in the OneNSF Framework are important parts of a diverse research portfolio that will both promote the progress of science and have far reaching societal impacts. Moreover, we think the initiative appropriately builds on existing programs, refocusing them to be more cost-effective while at the same time introducing new ideas in order to accomplish the goals set forth by both the Administration and Congress. NSF, with its long history of developing successful interdisciplinary research collaborations, is in the best position to address these priorities.

Question 2: Please explain the role private industry plays, in terms of creating and retaining science and engineering jobs, versus those types of positions funded with federal dollars? How do we ensure the science and engineering workforce continues to grow, perhaps better focusing this responsibility on the private sector?

Answer: Our Nation's economic and employment growth depends in large part on our capacity to innovate. Long-term national investments in basic and applied R&D play an important role in the flow of market-based innovations through a complex system that leverages the combined talents of scientists and engineers, entrepreneurs, business managers and industrialists. Innovation leads to economic and employment growth not only in high tech enterprises, but also in other industries that benefit from increased capabilities and productivity. Much of NSF's investment in basic research supports the training of the next generation of scientists and engineers who may use this knowledge to contribute to innovation in the private sector.

Federal investments in R&D have paid off in economic growth and generally improved the quality of life for Americans. The S&E workforce has had sustained a rapid rate of growth over decades. For example, the number of workers in S&E occupations grew from about 182,000 in 1950 to 5.4 million in 2009. This represents an average annual growth rate of 5.9%, much greater than the 1.2% growth rate for the total workforce during this period. In 2008, approximately 70% of individuals trained or working in S&E worked in the business/industry sector. The most recent occupational projections, for the period 2008–18, suggest that total employment in S&E occupations will increase (20.6%) at more than double the overall growth rate for all occupations.

Question 3: You and Dr. Suresh both testified that NSF is the only federal agency dedicated to the support of basic research and education in all fields of science and engineering and you went further to say that the basic research mission is the highest priority for the Foundation. What role did the Board play in the creation of I-Corps? Is there any concern by the Board that this program goes beyond the basic research mission of NSF?

Answer: With its oversight responsibilities for the Foundation, the Board engages thoroughly with NSF management in determining new endeavors. NSF, with the support of the Board, has pioneered public-private research partnerships such as the Small Business Innovation Research and Small Business Technology Transfer programs. The creation of I-Corps is another example of this strategy.

NSB recognizes basic research as the underpinning of the scientific enterprise. But the return on investment on NSF's research portfolio often needs a connection with other parts of the nation's scientific and technological enterprise, including applied research, education, technology transfer and development, innovation, and manufacturing. As a non-mission agency, NSF's extensive activities in basic research complement investments in other areas essential to the health of the scientific enterprise. We expect public-private partnerships, and investments such as I-Corps, will continue to be an essential component of science and engineering research and education supported by the Foundation and an important ongoing policy focus of the National Science Board.

Question 4: NSF has been identified as the "only federal agency dedicated to the support of basic research and education in all fields of science and engineering. Do you believe that some of the more applied areas of research identified in the America COMPETES Reauthorization Act, coupled with the multiple Administration applied priorities for NSF in the FY 13 budget request dilutes the funding for basic, fundamental research? Please explain your response.

Answer: One of the core duties of the NSB is to protect the Foundation's basic science, engineering and STEM educational missions while at the same time being mindful of its larger goals of advancing the

nation's health, prosperity, and welfare. Indeed, one of the primary purposes of our annual budget review is to assess the balance of the NSF's research portfolio.

In terms of the FY 13 budget request, we believe that both applied research and basic research are funded at appropriate levels. The 6.2% of the FY 13 budget requested for applied work is less than the NSF spent on this category in FY 12 (6.4%) and FY 11 (6.6%), and it is consistent with the 6.0% (on average) spent on applied research over the past 5 years. Thus, we think the FY 13 budget proposal reflects the same balance between applied and basic research that has served the Foundation well in the past.

However, the Board also feels that continued attention to this issue is warranted. The *SBIR/STTR Reauthorization Act of 2011*, enacted as part of P. L. 112-81, will increase the amount the NSF sets aside for these two programs from 2.8% combined in FY 11 to 3.05% in FY 13 to 3.65% in FY 17. As we develop future budget proposals, we will need to consider carefully how this 30% increase in the size of these applied programs fits into the Foundation's overall research portfolio.

Similarly, the *America COMPETES Reauthorization Act of 2010* (P.L. 111-358), directs the NSF to emphasize more applied research in some areas. The Foundation paid careful attention to these statutory charges in developing the FY 13 budget request and priorities. However, the NSB is aware that unbalanced or hasty pursuit of applied priorities has the potential to undermine NSF's core mission of promoting scientific progress. While the FY 13 budget request does not represent a departure from historical norms, these statutory changes necessitate increased attention to this concern in future budgets. We look forward to working with you to ensure that the NSF continues to support an appropriately balanced portfolio.

Question 5: The federal government has been funding STEM education for decades. Just over the past five years alone, we have spent over $16 billion on the issue. Every year, a larger emphasis is placed on the subject, and every year, we hear how we are falling further behind. What do we, as a Nation, have to show for all of the time, effort, and American taxpayer dollars that have already been devoted to this issue? What kind of return are we getting on our investment? How can we be confident that we are putting this money in the right place and on the right activities?

Answer: The Board has long been concerned with STEM education in the United States from kindergarten to graduate school and beyond. Over the past few decades, the Board has highlighted both the educational successes and challenges we face as a Nation for STEM education, and has offered policy recommendations aimed at helping to address these challenges in a variety of reports and statements.

Although much work remains, there has been improvement in many key areas due to the combined efforts of a wide range of interested stakeholders, including NSF. For example, from 1990 to 2007, average mathematics scores on the National Assessment of Educational Progress (NAEP) increased by 27 points for fourth graders. At grade 8, average mathematics scores steadily gained 20 points from 1990 to 2009, with improvement for most demographic groups, performance levels, and school types. High school graduates in 2009 continued an upward trend of earning more credits in mathematics and science, including advanced mathematics and science courses. For example, in 2009, 76% of all graduates earned a credit for algebra II, compared with 53% of all graduates in 1990. Increased rates were also seen in advanced chemistry 45% to 70%), biology (28% to 45%), and physics (24% to 39%).

While these results are positive, the Board continues to be concerned about data showing that U.S. elementary and secondary students' performance in science and mathematics trails that of their international counterparts. There are some instances where the U.S. is not necessarily falling behind—the U.S. is indeed making slow, but steady progress—but rather other countries are experiencing very rapid growth.

NSF has made substantial investments in STEM education research (e.g., STEM teacher pedagogy, effective STEM curricular tools, research into learning) in order to address the challenges within the U.S. STEM education system and move the education field forward. Broadly speaking, these investments help ensure that teacher training and classroom practice are rooted in the best available evidence with rigorous measures of success. By understanding "what works" in STEM education, NSF and the research community can direct their respective efforts towards areas of promise, ensuring that both money and time are spent most efficiently.

NSF has been a leader in making investments at the frontiers of education research with the goal of developing innovative strategies and tools to improve educational outcomes. Like its investments in basic S&E research, NSF's investments in cutting-edge education research creates a core knowledge base that serves as a reservoir from which all stakeholders (e.g., Federal and state agencies, researchers, education practitioners) can draw. A consistent challenge for education research is bringing these innovations to scale in schools throughout the United States. Consequently, NSF is making a concerted effort to facilitate this transition from research to wide-scale practice to maximize return on investments. For example, in FY 2013, the Widening Implementation and Demonstration of Evidence-based Reforms (WIDER) program will fund research and demonstration projects exploring widespread sustainable implementation of evidence-based undergraduate instructional practices to improve student outcomes. NSF also is enhancing efforts to integrate and leverage its own assets in STEM education and STEM disciplines through its "expeditions in education" (part of the "OneNSF" initiative).

Bringing evidence-based education research into wide-scale practice requires not just NSF efforts, but coordination with other Federal Agencies, such as the Department of Education (ED). In FY 2013, NSF is partnering with ED to launch an evidence-based initiative to improve K-16 mathematics education and knowledge building. This new endeavor will support researchers and educators who have the greatest potential to transform mathematics learning. NSF's contribution to this collaboration will be through support for the Discovery Research K-12 (DR K-12) and Transforming Undergraduate Education in STEM (TUES) programs. The TUES program, for example, aims to improve the quality of STEM education for all undergraduate students by supporting efforts to create, adapt, and disseminate new learning materials and teaching strategies to reflect advances both in STEM disciplines and in what is known about teaching and learning.

Importantly, NSF's support of STEM education has yielded significant returns beyond the educational gains described above. The Graduate Research Fellowship (GRF) program represents a long-standing, successful investment that has produced substantial tangible returns. The GRF program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in STEM disciplines relevant to the mission of NSF. Since its inception in 1952, the GRF program has supported 46,500 fellows, including 30 Nobel Laureates. These NSF-supported fellows are responsible for transformative breakthroughs in S&E research and have become leaders in their chosen careers. Their contributions have been crucial to maintaining and advancing the nation's technological infrastructure and national security, as well as contributing to the economic well-being of society.

Question 6: Since the beginning of 2012 both the Office and Science and Technology Policy (OSTP) and the GAO have issued reports on the number of STEM programs in existence across the federal government. Both reports found over 200 federal STEM programs (252 from OSTP and 209 from GAO) totaling over $3 billion dollars. What is the NSB doing to ensure the NSF's contribution is of the highest caliber basic research on STEM education? While the reports did not find direct duplication they did find overlap in much of these programs. How can we ensure federal dollars are being spent wisely and NSF investments are not duplicative of those at NASA, DOE or other federal agencies?

Answer: NSF has a unique role to play in the national STEM education ecosystem as the main agency that funds basic STEM education research. This basic research yields a scientific knowledge base for development of effective STEM education strategies and practices. The Board's Committee on Education and Human Resources (CEH) continually reviews and consults with NSF leadership on their strategies for investments in STEM education research. More generally, the Board establishes the merit review criteria by which all proposals to NSF are evaluated. The criteria emphasize that all NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.

In terms of avoiding duplication of STEM workforce development activities, the Board has examined and discussed recent STEM education reports from PCAST, the National Academies and others with an eye to ensuring NSF STEM education activities are complementary with and build constructively on those activities. Based on an analysis of these reports, CEH worked with NSF leadership to develop a set of STEM education priority items, to help NSF focus its activities related to inspiring and preparing STEM students and teachers.

With regard to avoiding duplication going forward, the Board has been kept apprised of progress as OSTP develops its 5-year strategic framework to coordinate federal STEM investments. NSF's Director, Dr. Subra Suresh, who is an ex officio member of the Board, co-chairs the National Science and Technology Council Committee on STEM (Co-STEM), which is developing the framework. The National Science Board will be involved in ensuring that future NSF STEM education efforts are consistent with the Co-STEM framework.

Appendix II

Additional Material for the Record

RESPONSE REQUESTED BY REPRESENTATIVE ANDY HARRIS,
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

Testimony Insert #1 Page 61a
Committee on Science, Space, and Technology
Subcommittee on Research and Science Education
February 28, 2012
An Overview of the National Science Foundation Budget for Fiscal Year 2013

NSF has been successfully supporting fossil fuel research for decades. In fact, the basic hydro-fracking discoveries that led to the modern-day techniques used to allow for commercial-scale extraction of natural gas from the large American domestic deposits were made by an NSF –funded team some thirty years ago, working on the Marcellus shale system in Pennsylvania.[1] Dr. Terry Engelder began looking into natural fracking to generate fractures in gas shale. With Dr. Gary Lash, he subsequently mapped the process in the Marcellus and other gas shale of the Appalachian basin. Work continues today in a newly-funded Science, Engineering, and Education for Sustainability (SEES) program grant to Penn State University and collaborators to investigate impacts and approaches to Marcellus Shale Gas Development.[2]

In another example, NSF-funded work at sea in the 1960's with the famous Glomar Challenger drilling research vessel led to our modern ability to "dynamically position" drilling vessels, thereby enabling deep wells to be constructed in choppy waters. This pioneering work was quickly converted by Shell Oil and other companies in the 1970's to deploy the first commercial Dynamical Positioning drilling vessels. For this work, NSF was elected as a Technology Pioneer in the Offshore Drilling Hall of Fame in 2009. These and other efforts have led the industry to today's dynamically-positioned drilling, production, construction, and pipe–lay barges that can operate in over 10,000 ft. water depths.[3]

Today, NSF remains involved in both continental and oceanic crust drilling research, designed, in part, to improve success in oil and gas exploration and production. Since 2005, NSF has provided support to Drilling, Observation and Sampling of the Earth's Continental Crust, Inc. (DOSECC), a not-for-profit corporation with 53 member organizations (mostly universities). DOSECC facilitates and supports cost-effective scientific drilling projects, which have important societal benefits including identification of natural resources. DOSECC also develops new drilling and sampling technology that has potential technology transfer benefits for the private sector. In 2010, NSF signed a Memorandum of Understanding with the American Association of Petroleum Geologists to further collaborate in operation of research facilities, education and outreach in the earth sciences, and in basic research related to minerals, energy, and groundwater. Current funded efforts include studies of methane hydrate deposits of potential commercial significance and of ways to apply nano technologies and nano materials to improve natural gas production.[4]

Projects are also underway to support cutting-edge chemical analysis techniques that will enable oil refiners to better evaluate oil quality and/or choose appropriate additives to prevent deposition inefficiencies. For example, NSF supports the National High Magnetic Field User Laboratory (NHMFL), a Florida State University, University of Florida, and Los Alamos National Laboratory collaboration, which runs seven programs including the Ion Cyclotron Resonance (ICR) for the above mentioned research. NHMFL, and in particular its ICR facility, has leveraged NSF-supported basic science and instrument development to attract industry interest and direct investment.

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[1] Engelder, NSF Award 8306146; Penn State University
[2] Brantley, NSF Award 110159; Penn State University
http://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=122543&org=NSF
[3] http://www.oceanstarocc.com/fame/2009/scienceandtechDP.html; http://www-odp.tamu.edu/glomar.html
[4] Wach, NSF Award 1134012; Lehigh University

There are many other examples. The Center for Enabling New Technologies through Catalysis (CENTC) scientists have invented and patented, and are bringing toward commercialization, catalysts that will convert light hydrocarbons into a class of heavy hydrocarbons known as FT Diesel.[5] FT diesel is much cleaner burning than conventional diesel, and much more energy-efficient than gasoline; thus, it is an ideal transportation fuel for automobiles, trucks, and jets. The NSF-supported Partnerships for Innovation (PFI) project led by Virginia Tech University[6] is driven by the potential for membrane separations to dramatically improve the global availability of clean water and clean natural gas. The knowledge gained in this project is being transferred to large and small companies through broad-based national and international workshops and collaborations.

NSF also supports these types of technologies through investments in the Small Business Innovation Research (SBIR) Program. One small business is working on x-ray technology targeted at the oil drilling industry.[7] This technology aims to provide powerful non-invasive analysis tools at well heads that will determine oil/water compositions in order to enhance oil drilling efficiency by precisely determining when the oil recovery is becoming uneconomical. This enabling technology has multiple applications, including gasoline and diesel combustion systems design and optimization for efficiency enhancements. Another small business award is aimed at decreasing the cost of oil production via better methods of cleaning produced water.[8] The project will convert pilot scale systems to treat produced water emanating from oil and gas production to commercial scale manufactured units. The technology is based on a swellable nano-engineered material with the ability to capture up to eight times its weight in organics via swelling.

Finally, NSF was heavily involved in the scientific diagnosis and evaluation of the recent Gulf Oil Spill, sending five NSF-funded vessels at different times to the gulf to conduct studies of oil flow, dispersal, and consequent effects on local ecosystems. The first NSF-funded peer-reviewed scientific papers on the oil spill actually appeared before the well was finally capped, attesting to the ability of NSF to mobilize the expertise of the U.S. research community in the national interest. These and other studies will help make the industry safer, more efficient, and more productive into the future. We are proud to take a holistic perspective on energy research in the national interest.[9]

In short, NSF research programs, in partnership with other agencies, provides many of the technological and scientific underpinnings for today's energy economy, including a growing and important emphasis on what is being called "green energy". NSF's diverse investment portfolio for fossil fuel research will undoubtedly reap large dividends for the Nation in decades to come.

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[5] Goldberg, NSF Award 1144108, University of Washington
[6] McGrath, NSF Award 0917971; Virginia Polytechnic Institute and State University
[7] Sivathanu, NSF Award 0923865; EN'URGA INC
[8] Jolly, NSF Award 1127225; Absorbent Materials Company LLC
[9] Dear Colleague Letter issued (http://www.nsf.gov/pubs/2010/nsf10060/nsf10060.jsp) and 100 + RAPIDS awarded.