NATIONAL SCIENCE FOUNDATION REAUTHORIZATION: PART I AND PART II

HEARINGS

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

COMMITTEE ON SCIENCE AND TECHNOLOGY

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

MARCH 20, 2007
and
MARCH 29, 2007

Serial No. 110–13
and
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Printed for the use of the Committee on Science and Technology

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NATIONAL SCIENCE FOUNDATION REAUTHORIZATION: PART I

TUESDAY, MARCH 20, 2007

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

The Subcommittee met, pursuant to call, at 10:35 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Brian Baird [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
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The Subcommittee on Research and Science Education

Hearing on:

"National Science Foundation Reauthorization: Part I"

2318 Rayburn House Office Building
Washington, D.C.

Tuesday, March 20, 2007
10:30 a.m. – 12:30 p.m.

WITNESS LIST

Dr. Arden Bement
Director
National Science Foundation

Dr. Steven Beering
Chairman
National Science Board

HEARING CHARTER

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

National Science Foundation Reauthorization: Part I

TUESDAY, MARCH 20, 2007
10:30 A.M.—12:30 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Tuesday, March 20, 2007, the Subcommittee on Research and Science Education of the House Committee on Science and Technology will hold a hearing to receive testimony from the Director of the National Science Foundation (NSF) and the Chair of the National Science Board (NSB) regarding pending legislation to reauthorize core activities, amend administrative laws and set new policy directions for NSF.

2. Witnesses

Dr. Arden L. Bement, Jr., Director of the National Science Foundation.

Dr. Steven C. Beering, Chairman of the National Science Board.

3. Overarching Questions

- What are the budget, administrative and policy issues that should be addressed through a 2007 NSF reauthorization bill?
- What is the appropriate balance between funding for interdisciplinary and disciplinary research? What are the best mechanisms for soliciting and funding interdisciplinary proposals? Is NSF doing a sufficient job of publicizing opportunities for funding in interdisciplinary research?
- The average success rate across the directorates is significantly lower for new investigators than for investigators previously funded by NSF. What can NSF do to narrow that gap? In particular, what funding mechanisms make the most sense without undermining the merit-review process, and what additional steps can NSF take to nurture young investigators?
- NSF, unlike the mission agencies, is a mainly proposal-driven agency. However, there are significant issues of concern to our nation—competitiveness, security, energy—that can be addressed, at least in part, through technology enabled by solutions or answers to known scientific challenges and questions. What is the appropriate role for NSF in such research motivated by national needs? In fostering industry/university partnerships? Is this a valid application of Criterion 2 of NSF's merit review process?

4. Brief Overview

- NSF currently has a budget of $5.9 billion and is the funding source for approximately 20 percent of all federally supported basic research conducted by America's colleges and universities. In many fields such as mathematics, computer science and the social sciences, NSF is the major source of federal backing.
- NSF also has a mission to achieve excellence in U.S. science, technology, engineering and mathematics (STEM) education at all levels and in all settings (both formal and informal) in order to support the development of a diverse and well-prepared STEM workforce and a well-informed citizenry.
- NSF is a proposal-driven (bottom-up) agency that operates almost exclusively by competitive merit-review. Reviewers are asked to evaluate proposals based

on two criteria: What is the intellectual merit of the proposed activity; and what are the broader impacts of the proposed activity?

- Breakthroughs in science and technology that will have a near to mid-term impact on society are increasingly requiring interdisciplinary teams of scientists and engineers willing and able to cross their traditional disciplinary boundaries. NSF has begun to react to the pressure from the community to re-evaluate its role in interdisciplinary research and education, but has not yet articulated a coherent path forward.
- New investigators have a 17 percent funding success rate, compared to a 28 percent success rate for prior investigators and an overall rate of 23 percent. The CAREER grant program was established explicitly to help find and fund outstanding young investigators, but CAREER awards differ from standard NSF awards in size, duration and evaluation criteria.
- The National Science Board recently eliminated cost-sharing for NSF awards, but certain award types are particularly suitable for industry or university cost-sharing. In addition, there are examples of industries eager to partner with universities to help fund the science to keep U.S. companies competitive and/or to solve particular technological challenges. The current policy appears to present an obstacle to NSF leveraging private dollars to conduct research in areas of national need.

5. Background

The National Science Foundation was established by Congress in 1950. The agency's mission is unique among the Federal Government's scientific research agencies in that it is to support science and engineering across all disciplines. NSF currently funds research and education activities at more than 2,000 universities, colleges, K–12 schools, businesses, and other research institutions throughout the United States. Virtually all of this support is provided through competitive, peer-reviewed grants and cooperative agreements. Although NSF's research and development (R&D) budget accounts for only about three percent of all federally funded R&D, the role of NSF in promoting fundamental research is vital to the Nation's scientific enterprise, as NSF provides approximately 20 percent of the federal support for basic research conducted at academic institutions. In many fields such as mathematics, computer science and the social sciences, NSF is the major source of federal backing.

The Foundation is administrated by a Director, who is appointed by the President and confirmed by the Senate and is responsible for the overall operations of the agency. The Foundation is overseen by the National Science Board, a body of 24 eminent scientists who are appointed by the President (with confirmation by the Senate) to serve six-year terms. Terms may be renewed but no member of the Board can serve more than 12 consecutive years. The role of the Board, as set forth in the *"National Science Foundation Act of 1950,"* is to establish the policies of the Foundation, provide oversight of its programs and activities, and approve its strategic directions and budgets.

NSF Budget by Functional Activities—The NSF budget can be divided into four general categories:

- Research project support funded through the Research and Related Activities (R&RA) account, which supports cutting-edge research;
- Facilities, funded through the Major Research Equipment and Facilities Construction (MREFC) account, which supports large, multi-user research facilities;
- Education and training, funded through the Education and Human Resources (EHR) account, which supports math and science education programs at the K–12, undergraduate, graduate, and postdoctoral levels, including programs to broaden participation in math and science; and
- Administration, which supports Agency Operations and Award Management (AOAM) and the Office of the Inspector General (IG) at NSF.

NSF is funded at $5.92 billion in fiscal year (FY) 2007, and the FY 2008 request is for $6.43 billion. Of that, $5.13 billion would be available for R&RA and $750 million for EHR. Under the President's American Competitiveness Initiative (ACI), funding for NSF, in particular for the research budget, would double in ten years (beginning with the FY 2007 budget)—a seven percent increase per year. (A detailed overview of the FY 2008 NSF budget request is attached.)

6. Budget Issues

Major Research Instrumentation

Major Research Instrumentation (MRI) is a funding line within R&RA to provide for the acquisition and development of mid-size instruments, ranging from $100,000 to $2.0 million. Presumably in response to a recent National Academy of Sciences (NAS) report[1] on this topic, NSF proposed raising the cap to $4.0 million in the FY 2008 request. The Committee is considering raising the cap even further to $20 million to better capture the full range of mid-size instruments required to advance scientific knowledge. Specifically, the NAS panel recommended that "NSF should expand its MRI program so that it includes Advanced Research Instrumentation and Facilities whose capital costs are greater than $2 million but that are not appropriate for NSF's Major Research Equipment and Facilities Construction (MREFC) account, which handles facilities that cost hundreds of millions of dollars." Typically the threshold for MREFC projects is 10 percent of the proposing directorate's budget, but most projects total much more. Given that the smallest research directorate has a budget of $200 million, a $4 million cap may be insufficient to meet this recommendation.

Funding pre-construction activities for major facilities

The MREFC budget funds the construction of large research facilities, such as telescopes and research ships. Congressional Appropriators required that funding for all pre-construction activities, including detailed design and costing work, come from the sponsoring research division rather than being available, at least in part, from the MREFC budget. All maintenance and operation (M&O) costs are also the responsibility of the sponsoring division. Unfortunately, because of the perennial trade-off between research and facilities, there is a long history of research divisions cutting corners on the pre-construction work, thereby underestimating or failing to minimize construction costs and/or M&O costs. It is not just a matter of inefficient use of resources—the scope of the science enabled by the facilities is sometimes scaled back in the face of escalating costs. The Committee is considering directing the Board to evaluate the appropriateness and trade-offs of the current policy for funding of pre-construction activities and report to Congress on their findings.

Education

While the President's ACI proposes to double research budgets, the education budget at NSF is seeing much smaller increases. By NSF's own accounting, overall funding for K–12 programs in the FY 2008 request falls by nine percent from the FY 2007 CR level. The Math and Science Partnerships (MSP) Program, and the Noyce Teacher Scholarship program, both of which address needs in K–12 education, would be level funded. The Course, Curriculum and Laboratory Improvement program, which is the core program in the Division of Undergraduate Education, is slowly decreasing in funding. (On the other hand, the STEM talent expansion program—a program to recruit undergraduates to STEM fields—would increase by 12–17 percent, depending on how NSF ends up distributing its FY 2007 EHR budget.) Such cuts or modest increases in funding are coming at a time when one report after another decries the state of K–12 STEM education, and U.S. industry is starting to raise concerns about the appropriateness of old paradigms in undergraduate education to major new developments in scientific understanding and practice.

7. Policies for Research Funding

Interdisciplinary research

"Training individuals who are conversant in ideas and languages of other fields is central to the continued march of scientific progress in the 21st century."[2] NSF, like all federal research agencies, is already funding interdisciplinary research. There are several cross-directorate and in some cases multi-agency programs, including: Cyber-enabled Discovery and Research (a new program for FY 2008), Cyberinfrastructure, Networking and Information Technology R&D (NITRD), and the National Nanotechnology Initiative (NNI), to name a few. The majority of NSF-funded Centers are also staffed by multi-disciplinary teams of scientists, engineers and educators. In addition, individual directorates have their own interdisciplinary and multi-disciplinary coordinating activities. For example, the Mathematical and Physical Sciences Directorate has a separate Office of Multi-disciplinary Activities,

[1] *Advanced Research Instrumentation and Facilities,* Committee on Advanced Research Instrumentation, National Academies Press, 2005.

[2] Robert Day, CEO of the Keck Foundation.

which facilitates, coordinates and co-funds multi-disciplinary and interdisciplinary activities between divisions, but does not directly manage any grants.

There is no standard definition for the term "interdisciplinary research." Furthermore, there is no standard delineation between interdisciplinary, multi-disciplinary and cross-disciplinary. In 2004, the NAS Committee on Science, Engineering and Public Policy issued a report on *Facilitating Interdisciplinary Research*. After reviewing the wide range of definitions in use, the NAS report panel settled on the following: "Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice." The panel distinguished between multi-disciplinary and interdisciplinary as follows: Multi-disciplinary teams join together to work on common problems, but may split apart unchanged when the work is done, while interdisciplinary teams may end up forging a new research field or discipline.

The issue of facilitating interdisciplinary research and pushing the frontiers of 21st Century science without compromising the potential for advances in disciplinary research or educating a generation of scientists and engineers without depth of knowledge in any single field is a complex and controversial one. Nevertheless, it is an issue at the forefront of the scientific enterprise and one that NSF and the rest of the scientific enterprise is struggling with.

Outside of the standing cross-directorate programs listed previously, most of the directorates process unsolicited interdisciplinary proposals from the bottom-up. This is a largely ad hoc process by which individual program officers receive proposals that they identify as interdisciplinary, decide to approach the program officer(s) in the appropriate division(s) relevant to the proposal, and work as a team to manage the review process, including putting together a review panel compromised of experts from all of the relevant fields. In some cases, instead of co-equal proposal managers, there may be a "principal" program officer with the others serving as advisors. There is no standard policy for handling interdisciplinary proposals across NSF. Whether or not it makes sense to institute a Foundation-wide policy rather than leaving the details to the heads of the directorates, NSF should be more clear in general about how they will balance interdisciplinary and disciplinary research moving forward, and they need to make clear to the scientific community how unsolicited interdisciplinary proposals are handled.

Young investigators

In the National Science Board's 2005 report on the NSF merit review process, they found that new investigators have a 17 percent funding success rate, compared to a 28 percent success rate for prior investigators and an overall rate of 23 percent. The Board identified the new versus prior investigator gap to be the "major gap" in success rates, while other demographic subgroups—in particular, women and minorities—were right at or even above the Foundation average.

The CAREER grant program was established explicitly to help find and fund outstanding young investigators, but CAREER awards differ from standard NSF awards in size, duration and evaluation criteria. In particular, there is an emphasis on the integration of research and education, which is not a required evaluation criterion for standard NSF research grants. The minimum CAREER award size is $400,000 for a five-year period. NSF-wide, the average annualized award amount for research grants in FY 2005 was $143,600, and the average duration is three years (range: one to five years).

Small Grants for Exploratory Research (SGER) awards were established in 1990 for small-scale grants awarded at the discretion of the program officers and without formal external review. NSF made 387 SGER awards in FY 2005 for a total of $27 million, and with an average size of $70,000. SGER awards are made, among other things, for preliminary work on untested ideas, and ventures into emerging research and potentially transformative ideas. Providing new investigators with seed money to make their proposals more competitive, for example with SGER funds, is one possible mechanism to help narrow the gap in success rates. Program officers may also be encouraged to take an active role in mentoring new investigators through the proposal and review process.

High-risk research

There is another potential benefit to NSF taking a more active role in supporting new investigators. Young investigators, on average, are more likely to take risks in their research than more established researchers. They don't yet have a base from which to build incrementally, they don't yet have a large cadre of graduate students,

post-docs and other lab personnel to support, and perhaps they are more willing and able by nature to think outside the box and take risks.

The National Science Board has called for a Foundation-wide transformative research initiative. The Board defines transformative research as "research driven by ideas that stand a reasonable chance of radically challenging our understanding of an important existing scientific or engineering concept or leading to the creation of a new paradigm or field of science or engineering. Such research is also characterized by its challenge to current understanding or its pathway to new frontiers." It is not clear what such an initiative would look like or how it would be carried out, but there is general agreement in the community that merit review panels are conservative by nature and that more effort needs to be made to fund high-risk research. Putting more effort into supporting young investigators is just one approach to addressing this need.

Research for national needs and industry partnerships

NSF, unlike the mission agencies, is a mainly proposal-driven agency. Some solicitations are narrowly defined by agency officials to address research needs they have identified, in particular in the context of government-wide initiatives such as NITRD and NNI, but the majority of directorate solicitations are broad in nature. The program officers rely on the scientific community itself to identify the most pressing or interesting research questions—hence the term "proposal-driven."

The mission-driven agencies, on the other hand, solicit mostly proposals that address specific challenges and questions identified by agency officials to address national needs. In the case of the Department of Energy (DOE), for example, agency officials work with industry to identify research priorities based on industry's and the government's outlook for energy demand and energy technology development, taking into account such factors as environmental and health impacts as well as geopolitics and security. Recently, the Office of Science at DOE began to formalize this process through a series of workshops with the full range of stakeholders to identify basic research needs for solar, hydrogen, nuclear, etc. In short, the mission and goals are narrowly identified from the top and the basic research needs are subsequently identified by the scientist community within those constraints.

NITRD, NNI and other such government-wide initiatives also focus on significant issues of concern to our nation—competitiveness, security, energy—that can be addressed, at least in part, through technology enabled by solutions or answers to known scientific challenges and questions. While NSF participates in and often leads these big initiatives, the Foundation rarely engages industry in identifying or supporting its own internal research priorities. There are some notable exceptions—the Engineering Research Centers, for example. And there are cases in which industry has stepped in uninvited and offered to supplement specific research grants because those forward-thinking industry leaders understand the importance of basic research to their own competitiveness.

Reporting of research results

The NSF Inspector General conducted a survey regarding NSF constituent interest in reporting of research results. The various constituent groups were overwhelmingly interested in NSF posting publication citations and brief summaries of research results on their public website, as other federal research agencies already do. The Committee would like to see the Director take the necessary steps to make this happen.

Cost-sharing

The Board recently decided to abolish cost-sharing for NSF research grants. They did so for two main reasons: to prevent NSF program officers from effectively forcing cost-sharing on universities by reducing funding amounts for successful grants but not reducing the scope of work; and to address the Inspector General's concern that NSF was not doing an adequate job of tracking whether proposed cost sharing actually materialized. However, this new policy raises concerns for some specific types of NSF programs, such as Engineering Research Centers (ERC's), which have always had substantial industry cost-sharing and the MRI program, for which university cost-sharing is not inappropriate. The Committee is considering: 1) exempting MRI explicitly; and 2) tasking the Board to examine the impacts of its ruling more broadly, in particular the impacts on programs that involve industry partnerships. (See discussion of industry partnerships above.)

8. Administrative Issues

Oversight role of the National Science Board

The National Science Foundation Act of 1950 created a Director to carry out the formulation of programs in conformance with the policies of the Foundation, and a National Science Board to establish the policies of the Foundation. While the role of the Board is considered by most to be both a policy-making and an oversight role, the word "oversight" never appears in statute. This lack of precision in existing statute has at times resulted in unproductive tension between the Board and the Director. The Committee is considering legislative language to more explicitly delineate the respective roles of the Director and the Board.

Board role in setting priorities for major research facilities

When proposals are submitted for major research facilities (i.e. facilities large enough to make it into the MREFC budget), the National Science Board, in the current process, is consulted after the conceptual design stage but gives its formal approval for the project only after the detailed design is complete. At that point the project may become an explicit part of the NSF's budget. As an oversight body, the Board should be involved in setting priorities for major facilities at an earlier stage in the process because of the long-term budget consequences, not just for construction costs but also for maintenance and operations costs.

APPENDIX

OVERVIEW OF FY 2008 NATIONAL SCIENCE FOUNDATION BUDGET

The National Science Foundation (NSF) is the primary source of federal funding for non-medical basic research conducted at colleges and universities and serves as a catalyst for science, technology, engineering, and mathematics (STEM) education reform at all levels. NSF is one of the research agencies that the President, in his 2006 State of the Union Address, proposed to double over ten years as part of the *American Competitive Initiative* (ACI). The FY 2007 budget request, which called for a $439 million (7.9 percent) increase over the FY 2006 budget, was the first to reflect the ACI. The FY 2008 request maintains that general trend with a $409 million (6.8 percent) increase over the FY 2007 request, although the increases are not distributed evenly.

The FY 2007 CR would fund NSF at $5,916 million, a $335 million (6.0 percent) increase from FY 2006, but a $105 million (1.7 percent) decrease from last year's request. Specifically, the CR appropriates $4,666 million for the Research and Related Activities (R&RA) account, and remains silent on the rest of the NSF accounts, signaling a continuation of FY 2006 funding levels for those accounts.[3] The FY 2008 request of $6,429 million is $848 million (15.2 percent) greater than FY 2006 spending and $513 million (8.7 percent) greater than FY 2007 spending under the CR.

Research and Related Activities (R&RA)

Scientific research programs and research facilities (which comprise the R&RA account) receive a $367 million (7.7 percent) increase from FY 2007. The increases for scientific research are spread fairly evenly among all fields NSF supports. The largest percentage increases are for the math and physical sciences, computer sciences, and engineering directorates. The two directorates that receive percentage increases below the total R&RA increase are the (non-medical) biological sciences and the social, behavioral and economic sciences.

NSF's contribution to the multi-agency National Nanotechnology Initiative increases by $17 million (4.5 percent), including $3 million more in support of research on the environmental, health and safety (EHS) aspects of nanotechnology. In particular, support is requested for a new, multi-disciplinary center to conduct EHS research and provide the science needed to inform the development of regulations.

The FY 2008 budget also requests support for two new research initiatives, including $52 million for an NSF-wide program (known as CDI) to develop the computational tools and knowledge necessary to handle data-rich, highly complex systems and phenomena, such as the flow of information over the Internet, or major storms, and $17 million for a multi-agency program for understanding ocean dynamics, forecasting ocean events, and managing ocean resources. The CDI funding, in combination with the $47 million in increased funding for cyberinfrastructure, provide the $90 million (10 percent) increase in the NSF contribution to the coordinated, interagency research initiative in information technology (known as NITRD).

The award cap for the funding of mid-size research instrumentation under the Major Research Instrumentation (MRI) program is raised from $2.0 to $4.0 million, in response to a 2005 recommendation by the National Academy of Sciences. The total funding level for the MRI program is increased by $26 million (29.5 percent) to $114 million.

Since FY 2006, under a Memorandum of Agreement, NSF has been responsible for reimbursing the U.S. Coast Guard for the costs of the icebreakers that support scientific research in the polar regions. The FY 2007 CR explicitly requires NSF to continue honoring this agreement. The request for FY 2008 is $57 million, the same as it was for FY 2007. NSF also purchases back-up ice-breaking services on the open market at a cost of approximately $8 million per year.

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[3] In the FY 2008 NSF budget presentation, the Experimental Program to Stimulate Competitive Research (EPSCoR) is moved from the Education account to the R&RA account. This change is reflected in the comparisons and budget table for the prior years. The FY 2007 CR provided funding for the components of R&RA included in the FY 2007 NSF request, which did not include EPSCoR. The amount shown here for R&RA under the FY 2007 CR has been increased by the EPSCoR funding for FY 2006 ($98.7 million) and the amount under Education and Human Resources (EHR) has been similarly reduced.

Major Research Equipment and Facilities Construction (MREFC)

The MREFC activity funds the construction of large research facilities, such as telescopes and research ships. Funding for the operation and management of these major user facilities is included in the R&RA budget.

The FY 2008 request provides an increase of $54 million (28.2 percent) for MREFC, which will allow for continuation of support for six construction projects and one new start. The new project, which is funded at $33 million in the first year, will provide for an upgrade to increase the sensitivity of an earth-based observatory for the study of gravitational waves.

Three new projects proposed under last year's request are currently on hold due to funding uncertainties. Under the CR funding levels, NSF would be able to proceed on schedule with the two smaller projects (the National Ecological Observatory Network and Ocean Observatories Initiative), but would have only $6 million of the $56 million requested for the Alaska Region Research Vessel (ARRV). *[report due March 15- might have approval by then]*

Education and Human Resources (EHR)

EHR funds most of NSF's activities that support K–12 STEM education and the majority of activities that support undergraduate STEM education. EHR also funds most of NSF's graduate fellowship and traineeship programs.

The FY 2008 EHR budget request is $751 million, a $34 million (4.8 percent) increase from the FY 2007 request and a $53 million (7.5 percent) increase from the FY 2007 CR level (FY 2006 appropriation level). Most of this proposed funding increase goes to increases in graduate research fellowships (+ $11.2 million) and in activities to broaden participation in STEM fields (+ $28.6 million). NSF has also launched a concerted effort to evaluate program effectiveness across EHR, and in particular, for its STEM education programs and projects.

For K–12 education programs, the budget request is a good news/bad news story. After proposing in the past two budgets to eliminate the Math and Science Partnership (MSP), this year's request would provide level funding at the FY 2007 request of $46 million, which is still $17 million less than FY 2006 spending.[4] Since there have been very few new starts during the past two years, the requested funding level will provide $30 million for new starts in FY 2008. However, overall funding for K–12 programs in the FY 2008 request falls by nine percent from the FY 2007 CR level.

Agency Operations and Award Management

This NSF account, previously called Salaries and Expenses, funds the internal operations of NSF. The FY 2008 request provides an increase of $39 million (15.7 percent) above the FY 2007 CR.

NSF is facing the challenge of expanding its workforce to accommodate the demands created by the growing research budgets. H.J. Res. 20 would delay many planned new-hires in addition to planned upgrades of the electronic system used to receive and process grant applications. Most of the $39 million increase for agency operations and award management in the FY 2008 budget request are slated for these two needs.

[4] It remains unclear how FY 2007 actual spending for MSP will be affected by the CR, since the FY 2007 request, in this case, was much lower than FY 2006 spending. However, it is likely that NSF will be guided by their FY 2007 request in making this decision.

National Science Foundation
FY 2008 Budget Request (dollars in millions)
(Source: Agency Budget Justification)

NSF Program Activity	FY06 Current Plan	FY07 Request	FY07 House-passed CR	FY08 Request	Change FY07 House CR to FY08	
					Amount	Percent
R&RA	**4431**	**4766**	**4765**	**5132**	**367.0**	**7.7%**
BIO	581	608	608	633	25.2	4.1%
CISE	496	527	527	574	47.3	9.0%
ENG	585	629	629	683	54.8	8.7%
GEO	704	745	745	792	47.2	6.3%
MPS	1087	1150	1150	1253	102.7	8.9%
SBE	201	214	214	222	8.2	3.9%
OCI	127	182	182	200	17.6	9.6%
OISE	43	41	41	45	4.4	10.8%
OPP	391	438	438	465	26.8	6.1%
Logistical Support	*67*	*68*	*68*	*68*	0	0%
Icebreakers	*60*	*57*	*57*	*57*	0	0%
IA	233	231	231	263	32.0	13.9%
USARC	1.2	1.5	1.5	1.5	0.0	2.8%
EHR	**698**	**716**	**698**	**751**	**52.6**	**7.5%**
MREFC	**191**	**240**	**191**	**245**	**53.9**	**28.2%**
AOAM	**247**	**282**	**247**	**286**	**38.8**	**15.7%**
OIG	**11.4**	**11.9**	**11.4**	**12.4**	**1.0**	**8.7%**
NSB	**3.95**	**3.91**	**3.95**	**4.03**	**0.1**	**2.0%**
Total	**5581**	**6020**	**5916**	**6429**	**513.4**	**8.7%**

Acronyms:
R&RA = Research and Related Activities
EHR = Education and Human Resources
MREFC = Major Research Equipment and Facilities Construction
AOAM = Agency Operations and Award Management (Previously Salary and Expenses)
OIG = Office of the Inspector General
NSB = National Science Board
BIO = Biological Sciences
CISE = Computer and Information Science and Engineering
ENG = Engineering
GEO = Geosciences
MPS = Mathematical and Physical Sciences
SBE = Social, Behavioral, and Economic Sciences
OCI = Office of Cyberinfrastructure
OISE = Office of International Science and Engineering
OPP = Office of Polar Programs
IA = Integrative Activities
USARC = U.S. Arctic Research Commission

Chairman BAIRD. This hearing will come to order.

I want to welcome our distinguished guests and visitors here to the first of two Research and Science Education Subcommittee Hearings dedicated to the development of legislation to reauthorize programs at the National Science Foundation.

Today, we will hear from the distinguished Director of the National Science Foundation and the Chair of the National Science Board. Next week, we will hear from a diverse panel of outside witnesses who will weigh in on some of the broader issues we hope to address through this legislation, including support for young investigators, NSF's important role in science, technology, engineering, and mathematics (STEM) education, the industry's role in supporting basic research and the future of interdisciplinary research.

As part of our hearing today, I hope we will look at the issue of young investigators. In fiscal year 2006, new investigators achieved an 18 percent funding success rate compared to a returning investigative success rate of 30 percent and an overall agency rate of 25 percent. I know that NSF is making it a priority to narrow this gap and that it supports outstanding, young investigators through the very prestigious CAREER grants program. However, I also believe that more can be done to nurture and support new researchers and that we need to be creative in figuring out ways to keep bright, young researchers in the pipeline. For this reason, the Committee is considering creating a new pilot program of seed grants to new investigators to give them an opportunity to strengthen their proposals before resubmitting them through the merit review process.

Another topic of particular interest to us today is industry's role in funding basic research. There are leaders in the high-tech industry that understand that their future depends, in large part, on the scientific advances made by researchers in university labs across the country. Unfortunately, however, many in industry fail to see, or ignore, the potential for university-industry partnerships to further their own success and competitiveness. NSF can play a significant role in changing attitudes and fostering partnerships by providing incentives to both university researchers and private sector officials to bridge this divide and encourage participation and research.

This committee is also quite concerned about the slow growth, and in some cases, shrinking budget of STEM education programs at NSF. Chairman Gordon has introduced legislation to strengthen and broaden existing K–12 STEM education programs at NSF, in particular, Noyce Teacher Scholarship program, the Math and Science Partnership, and the STEM Talent Expansion Program. Today, I would like to spend time discussing STEM's—or NSF's role in STEM education, including technological training at two-year colleges through the Advanced Technological Education Program. And I might interject, also, that I am very grateful for Dr. Cora Marrett visiting my district last week and meeting with a number of educational leaders throughout the spectrum. Dr. Marrett, it was a pleasure to have you out there, and I am glad you managed to get home in spite of the travel difficulties.

Today, I also hope that we will explore the concept of interdisciplinary research. The frontiers of 21st century science are very much dominated by what most would consider to be interdiscipli-

nary research, research conducted by teams of scientists that integrate information, data, methods, perspectives, and theories from two or more bodies of specialized knowledge to advance fundamental understanding or solve problems beyond the scope of a single discipline. Without compromising the strength of the individual discipline or the ability of the lone scientists to make great advances on narrow topics within his or her own field, we need to also make sure that interdisciplinary proposals get a fair hearing. NSF has shown a great leadership on this issue, but I believe there are ways to better define this process and look forward to ongoing discussions with the agency and the community on ways to go about this.

I should add that many of these issues that we must deal with in the context of NSF reauthorization are issues that the greater community is also grappling with, however, because NSF funds 20 percent of basic research at U.S. colleges and universities across all science and engineering disciplines and because NSF continues to be at the forefront of the ever-evolving scientific enterprise, they are issues of particular importance to me, to this subcommittee, and to the NSF.

In addition to some of these broad issues, we will also take a look today at some specific budget and administrative issues at the Foundation, some of which are long-standing issues of concern and others of which have been brought to the attention of the Committee more recently.

I want to note that this committee supports the Administration's proposal to double funding for basic science research over a 10-year period, and the authorization levels that we will propose are aligned with the Administration's plans. However, I also want to suggest that we can't afford to keep playing this game of increasing funding for one set of disciplines while decreasing or flat-lining funding of others. We will continue to advocate for increased fundings for basic and applied research across the board, but we need help from the entire scientific community in justifying such increases to the rest of our colleagues in Congress and to the American taxpayer as well.

We must also recognize that these are tight budget times. We can't simply throw money at science because we want to. We need to maintain diligence in ensuring that the research we fund is of top quality, that federally-funded researchers are held to the highest standards of ethical conduct of research, and that we are thoughtful in setting priorities for research funding.

Finally, I want to be clear that the process for developing NSF reauthorization bill is to be open, transparent, and responsive to all concerned parties, both within and outside the government.

I welcome your suggestions and encourage you to be in touch with me with your thoughts or ideas, and that is the broad, you, not just our witnesses today, but others that are here in the audience or in the scientific community. We welcome their feedback and their suggestions.

Dr. Bement, Dr. Beering, thank you for being here with us today. I look forward to hearing your testimony, to receiving your input and guidance as we develop this NSF reauthorization legislation,

and thank you both for your leadership on the Foundation and the Board.

And I now yield to my colleague, Ranking Member Ehlers, for his opening remarks.

[The prepared statement of Chairman Baird follows:]

PREPARED STATEMENT OF CHAIRMAN BRIAN BAIRD

Good morning. I want to welcome you to the first of two Research and Science Education Subcommittee hearings dedicated to the development of legislation to reauthorize programs at the National Science Foundation.

Today, we will hear from the distinguished Director of the National Science Foundation and the Chair of the National Science Board.

Next week, we will hear from a diverse panel of outside witnesses who will weigh in on some of the broader issues we hope to address through this legislation—including support for young investigators, NSF's important role in science, technology, engineering and mathematics (STEM) education, the industry's role in supporting basic research, and the future of interdisciplinary research.

In fiscal year 2006, new investigators achieved an 18 percent funding success rate, compared to a returning investigator success rate of 30 percent and an overall Agency rate of 25 percent. I know that NSF is making it a priority to narrow this gap, and that it supports outstanding young investigators through the very prestigious CAREER grants program. However, I believe that more can be done to nurture and support new researchers and that we need to be creative in figuring out ways to keep bright young researchers in the pipeline. For this reason, the Committee is considering creating a pilot program of seed grants to new investigators to give them an opportunity to strengthen their proposals before resubmitting them through the merit review process.

Another topic of particular interest to me is industry's role in funding basic research. There are some leaders in high-tech industries that understand that their future depends in large part on the scientific advances made by researchers in university labs across the country. Unfortunately, however, most in industry fail to see, or ignore, the potential for university-industry partnerships to further their own success and competitiveness. NSF can play a significant role in changing attitudes and fostering partnerships, by providing incentives to both university researchers and private sector officials to bridge this divide and encourage industry participation in research.

This subcommittee is also very concerned about the slow growth, and in some cases shrinking, budgets of STEM education programs at NSF. Chairman Gordon introduced legislation to strengthen and broaden existing K–12 STEM education programs at NSF, in particular the Noyce Teacher Scholarship program, the Math and Science Partnerships and the STEM Talent Expansion program. Today, I would like to spend time discussing NSF's role in STEM education, including technical training at two-year colleges through the Advanced Technological Education program.

Today, I also hope that we will explore the concept of interdisciplinary research. The frontiers of 21st Century science are very much dominated by what most would consider to be interdisciplinary research—that is, research conducted by teams of scientists that integrate information, data, methods, perspectives and theories from two or more bodies of specialized knowledge to advance fundamental understanding or solve problems beyond the scope of a single discipline. Without compromising the strength of the individual disciplines or the ability of the lone scientist to make great advances on narrow topics within his or her own field, we need to make sure that interdisciplinary proposals get a fair hearing. NSF has shown great leadership on this issue, but I believe that there are probably ways to better define this process. I look forward to ongoing discussions with the Agency and the community on ways to go about this.

I should add that many of these issues and others that we must deal with in the context of the NSF reauthorization bill are issues that the greater scientific community is also grappling. However, because NSF funds 20 percent of the basic research conducted at U.S. colleges and universities, across all science and engineering disciplines, and continues to be at the forefront of the ever-evolving scientific enterprise, they are issues of particular importance to me, to this subcommittee, and to NSF.

In addition to some of these broad issues, we will also take a look today at some specific budget and administrative issues at the Foundation—some of which are

longstanding issues of concern, and others of which have been brought to the attention of the Committee more recently.

I want to note that this Committee supports the Administration's proposal to double funding for basic physical science research over a ten-year period, and the authorization levels that we will propose for NSF are aligned with the Administration's plans. However, I also want to suggest that we can't afford to keep playing this game of increasing funding for one set of disciplines while decreasing or flatlining funding for others. We will continue to advocate for increases in funding for basic and applied research across the board, but we need help from the entire scientific community in justifying such increases to the rest of our colleagues in Congress.

We must also recognize that these are tight budget times. We can't just throw money at science because we want to. We need to maintain due diligence in ensuring that the research we fund is of top quality, that federally-funded researchers are held to the highest standards for ethical conduct of research, and that we are thoughtful in setting priorities for research funding.

Finally, before I close, I want to be clear that I want the process of developing the NSF reauthorization bill to be open, transparent and responsive to all concerned parties both within and outside of government. I welcome your suggestions, and encourage you to be in touch with me with your thoughts or ideas.

Dr. Bement and Dr. Beering, thank you for being here today. I look forward to hearing your testimony today and to receiving your input and guidance us as we develop this NSF reauthorization legislation.

And I now yield to my colleague, Ranking Member Ehlers for his opening remarks.

Mr. EHLERS. Thank you, Mr. Chairman.

And thank you, gentlemen, for being here, representing one of the finest institutions of the Federal Government, and, perhaps, the finest.

You will find this to be a friendly committee, I am sure, certainly more friendly than much of the rest of the Congress, not that anyone dislikes you, but they all say they like you but don't provide money for you. We will continue to try to do what we can to not only like you but provide money for you.

I am pleased to participate in the Research and Science Education Subcommittee's first hearing of this Congress to address the reauthorization of the National Science Foundation. The goals of reauthorization are to improve the functioning of an agency known for both high-caliber research output and internal efficiency, which makes our job somewhat more challenging than trying to improve upon an agency with glaring shortcomings.

Finding areas in need of improvement can be best achieved from hearing from expert witnesses, like those before us today and the NSF consumers who will testify at the end of the month in a second hearing. When finding areas for strengthening and improvement, I believe we must remain cognizant of the uniqueness of the National Science Foundation. What goes for other agencies may not necessarily apply to NSF.

I know the Committee is interested in exploring some of the relationships the National Science Foundation has established with industry, and I am keenly interested in encouraging these relationships while maintaining the quality of NSF fundamental research.

As current researchers know, potential applications are important but should not dictate research design exclusively.

Chairman Baird and I share concerns in several areas of NSF, including maintaining the integrity and capacity of the peer-review process, managing increasingly interdisciplinary research portfolios, and educating our future workforce in all STEM-related jobs,

not just those historically identified as science and engineering careers.

Finally, I look forward to hearing about the NSF's preparations for future funding increases that this committee has worked tirelessly to authorize and ultimately see supported through the appropriations process.

And I certainly also share the Chairman's concern about the young scientists and certainly encouraging them so that they can get their feet in the door, begin their tenure track before they lose their position for lack of funding of their research.

I thank Dr. Bement and Dr. Beering for being here today, and I look forward to your testimony.

[The prepared statement of Mr. Ehlers follows:]

PREPARED STATEMENT OF REPRESENTATIVE VERNON J. EHLERS

I am pleased to participate in the Research and Science Education Subcommittee's first hearing of this Congress to address the reauthorization of the National Science Foundation. The goals of reauthorization are to improve the functioning of an agency known for both high-caliber research output and internal efficiency, which makes our job somewhat more challenging than trying to improve upon an agency with glaring shortcomings. Finding areas in need of improvement can be best-achieved by hearing from expert witnesses like those before us today, and the NSF consumers who will testify at the end of the month in a second hearing.

In finding areas for strengthening and improvement, I believe we must remain cognizant of the uniqueness of the National Science Foundation. What goes for other agencies may not necessarily apply to NSF. I know the Committee is interested in exploring some of the relationships NSF has established with industry, and I am keenly interested in encouraging those relationships while maintaining the quality of NSF fundamental research. As current researchers know, potential applications are important but should not dictate research design exclusively.

Chairman Baird and I share concerns in several areas of NSF, including maintaining the integrity and capacity of the peer review process; managing increasingly interdisciplinary research portfolios; and educating our future workforce in all STEM-related jobs, not just those historically identified as science and engineering careers. Finally, I look forward to hearing about NSF's preparations for future funding increases that this Committee has worked tirelessly to authorize and, ultimately, see supported through the appropriations process.

I thank Dr. Bement and Dr. Beering for being here today and look forward to their testimony.

Chairman BAIRD. If there are other Members who wish to submit additional opening statements, your statements will be added to the record.

[The prepared statement of Mr. Carnahan follows:]

PREPARED STATEMENT OF REPRESENTATIVE RUSS CARNAHAN

Mr. Chairman, thank you for holding the first hearing on the National Science Foundation (NSF) Reauthorization.

NSF holds a tremendously vital national role, funding research and education activities at more than 2,000 universities, colleges, K–12 schools, businesses and other research institutions across the U.S. The mission of NSF, which is to support science and engineering across all disciplines, is on impressive display in my home congressional district including the St. Louis region.

St. Louis houses nearly half of the NSF award recipients in the state of Missouri. I am proud of the great STEM work being done in our area, specifically at the NSF-funded Danforth Plant Science Center, St. Louis University, St. Louis Science Center, University of Missouri at St. Louis, Washington University and Washington University School of Medicine. I look forward to continued growth in the important field of STEM research.

Thank you for being here today, Drs. Bement and Beering. I look forward to hearing your testimony.

[The prepared statement of Mr. Bilbray follows:]

PREPARED STATEMENT OF REPRESENTATIVE BRIAN P. BILBRAY

Dear Chairman Baird and Ranking Member Ehlers:

Thank you both very much for holding this hearing to review the National Science Foundation (NSF). This agency is a key component of America's quest to be the world leader in scientific innovation. I look forward to hearing from NSF Director Arden Bement and National Science Board (NSB) Chairman Dr. Steven Beering.

Today, the United States is the world superpower when it comes to scientific innovation and talent. Our great nation leads the rest of the world in high expectation entrepreneurship and research and development spending. The United States is the location of the world's high technology manufacturing output. However, as Tom Friedman, distinguished author of *The World Is Flat* notes, globalization has "accidentally made Beijing, Bangalore and Bethesda next door neighbors." Other nations are beginning to imitate the U.S. research enterprise success and if we rest on our laurels, we will soon be playing catch-up in the race to develop the latest innovative products, which will generate wealth and create domestic security.

For more than 50 years, the National Science Foundation has been the premier federal agency in support of basic research. Every year, NSF supports nearly 35,000 awards supporting a wide spectrum of those seeking to understand our most complex scientific mysteries. From the teacher working to generate interest in the next great generation of scientists to the university researcher seeking to advance organ transplantation by studying frog physiological processes in freezing weather, NSF is a diamond in the Federal Government crown.

As we continue into the 21st century, it will be imperative for our nation to recognize the unique value that interdisciplinary research plays. No longer can we ignore the relationship that the unique parts of the scientific enterprise have in producing breakthroughs. Today, biomedical innovation is increasingly taking place at the intersection of traditional health sciences like biology and fields such as computational science and engineering. But we are seeing a startling trend of newly minted grads that lack the technical skills to carry out applied research in the areas that straddle engineering, math and computers. For your information, I am attaching a *Business Week* article highlighting this problem. If we are truly going to be competitive in this global economy our scientists must learn to work together and form collaborations. The Committee has recognized this importance by tasking the National Science Board with evaluating the current and potential role of NSF in supporting interdisciplinary research. I look forward to reading the NSB's report to Congress.

I am pleased to see that the Act before us addresses the three pillars of innovation: funding, talent and infrastructure. The current bill authorizes on average an eight percent increase for NSF for the next three years, provides $94 million for vital math science partnerships and $44 million for STEM (Science, Technology, Engineering, and Mathematics) talent programs. Our nation deserves the best opportunity at a healthy existence and this legislation could be the start in providing that.

I look forward to working with the National Science Foundation and my colleagues on this panel to pass an effective reauthorization bill which will enhance an already outstanding agency.

ARTICLE APPEARING IN *Business Week*

NOVEMBER 6, 2006
SCIENCE & TECHNOLOGY

Biotech's Beef

BY NICHOLA SAMINATHER

Companies say grad schools aren't stressing what students require in the real world.

The U.S. is the mecca of biotech. Most top companies in the field are based here. Government research budgets in biology are immense and growing. Universities compete to attract great professors. Students flock to their courses. And once they're armed with graduate degrees, they can count on landing a job in the industry.

Or can they? In recent months biotech outfits have begun to complain that job applicants coming out of U.S. universities lack the know-how companies seek. Left unresolved, the troubles could stifle growth in this booming sector, valued at $48 billion last year by consultant Ernst & Young. The knowledge deficiencies could also

force biotech companies to move more of their operations overseas, say executives and recruiters.

The problem is a disconnect between what universities are teaching and what biotech wants. "The focus of academia is getting basic and theoretical knowledge in place," says E. Dale Sevier, a director at the California State University Program for Education & Research in Biotechnology. "The skills needed to be successful in the industry are just not taught in universities."

There are several weaknesses. First, recent grads lack the technical knowledge to carry out applied research in areas that straddle engineering, math, and computers. Second, job candidates have little awareness of what the Food & Drug Administration is looking for when it considers whether or not to approve a drug. Recent grads simply aren't familiar with issues such as quality control and regulatory affairs. Academic programs "don't train students to function in today's small-R, large-D environment," says Stephen Dahms, President and CEO of the Alfred E. Mann Foundation for Biomedical Engineering.

The California State University biotech program tried to identify what companies want from new hires in a 2000 report. Close to the top of the list are familiarity with FDA compliance, experience in clinical trial design, and quality control. All require knowledge of computing, statistics, and database management—pretty low priorities for most academic biotech programs.

As it happens, these are common credentials for foreign researchers in the U.S. who hold temporary work papers known as H–1B visas. U.S. Citizenship & Immigration Services reports that 3.6 percent of all H–1B visas for 2003, a total of 7,119, went to employees in scientific research and development. Some 80 percent of them have graduate degrees from U.S. universities, Dahms says, but "there's something special about the prior exposure of foreign nationals. They have a more applied R&D perspective." Of course, there are smart U.S.-born candidates with good math and computer skills. But they're rarely fluent in both math and life sciences.

Invitrogen Corp. (IVGN), a biotech company in Carlsbad, Calif., currently employs about 75 H–1B visa holders in a workforce of 5,000, and it needs more. The company hired 1,000 people last year and will raise that to 1,400 this year. But with H–1B quotas filling up earlier every year, Invitrogen has chosen to do more drug development in Japan, China, and India. It may also open facilities in Korea and Singapore, says Rodney Moses, Invitrogen's Vice-President of Talent Acquisition. Compensation in China and India is lower than in the U.S., but that's not what motivates the move offshore, says Moses. "If the talent is located in Singapore, it's just easier for us to go there."

U.S. colleges take the problem seriously. State university systems in California, Wisconsin, and elsewhere are adding more industry-oriented classes. California State has crafted a curriculum that includes chemistry, engineering, and computer science. A new biotech program at the University of Wisconsin's Stout campus offers statistics and technical writing. Students must also work full-time at a biotech company during the summer or for a semester.

Industry buys into this idea. Invitrogen is sponsoring occupational summer camps for high school students, hoping to nudge them into taking more science and math courses. Many other companies are setting up intern and apprentice programs to identify promising students and prepare them for a post-academic career. After all, the goal in industry isn't just to raise interesting questions, as in academia. It's to find the answers.

Chairman BAIRD. At this time, I would like to introduce our two witnesses.

Dr. Arden Bement is Director of the National Science Foundation. He became the Director in 2004 after having served more than two years as Director of the National Institute of Standards and Technology. Dr. Steven Beering is the Chair of the National Science Board. He has served on the Board since 2002, and was elected Chairman in 2006. Before retiring in 2000, he served for 17 years as President of Purdue University in Indiana.

As our witnesses both know well, spoken testimony is limited to five minutes each, after which Members of the Committee will have five minutes each to ask questions. And we will start with Dr. Bement.

Again, thank you, gentlemen, both for being here.

STATEMENT OF DR. ARDEN L. BEMENT, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. BEMENT. Chairman Baird, Ranking Member Ehlers, and Members of the Committee, thank you for the opportunity to testify before you today.

You have raised a number of important issues in your invitation letter and I commend you both for taking an active role in promoting a discussion of these questions.

Before I address some of your specific questions, I want to let you know how much I appreciate your strong statements of support for our fiscal year 2008 budget request. As you know, the request will provide an 8.7 percent increase over the continuing resolution. Funding at this level will keep NSF on the course set by the President's American Competitiveness Initiative to drive innovation and sharpen America's competitive edge.

Let me move on to the specific issues you have raised.

The first is in regard to NSF's efforts to nurture young investigators.

We take this responsibility very seriously and address it in a variety of ways.

Our signature Faculty Early Career Development Program, called CAREER, is our most prestigious award in support of the early career-development of young investigators. Successful applicants must effectively integrate research and education within the context of their organization's mission. NSF provides 400 new CAREER awards annually, each for a duration of five years, to some of the best and brightest young researchers in the country. Each year, NSF nominates the most meritorious new CAREER awardees for the Presidential Early Career Awards for Scientists and Engineers, called PECASE. This presidential award is the Nation's highest honor bestowed on scientists and engineers beginning their careers.

NSF also engages in a variety of outreach efforts to support and nurture young investigators. Our NSF Days program provides workshops to assist investigators in understanding the process of submitting proposals to NSF. Over the past five years, we have sponsored 40 workshops that have attracted nearly 6,000 participants.

Additional outreach efforts pair NSF program officers with researchers whose proposals had been declined in an effort to improve proposals for subsequent resubmission.

The effectiveness of these efforts is shown by the fact that the share of grants to new investigators has remained stable at about 28 percent over the past decade, although the overall success rate has declined from around 30 percent to 21 percent. In that same period, the proportion of grantees receiving an award within seven years of their last degree has also remained stable at about 74 percent.

Let me quickly move on to the matter of an appropriate balance between interdisciplinary and disciplinary research.

Support for interdisciplinary research is a priority for the NSF because it presents a tremendous opportunity for innovation. Finding the proper balance results from discussions with the National Science Board and through feedback from our many stakeholders.

NSF's Centers and the priority areas outlined in our budget also serve as catalysts for generating interdisciplinary proposals.

We continually make a strong effort to communicate our interest in supporting interdisciplinary research. The flexibility of NSF's merit review process allows program officers to use multiple approaches to meet the challenge of reviewing interdisciplinary proposals. In some cases, mail reviews are used to provide deep expertise on various aspects of proposals. Panel reviews are often used to integrate reviews from different disciplinary perspectives and to provide a broader interdisciplinary overview.

Recognizing interdisciplinary proposals poses little difficulty, especially when they are submitted in response to a specific solicitation. FastLane, our electronic grant application process, also gives PIs an opportunity to select multiple programs to consider their proposal.

In fiscal year 2004, the National Science Board initiated a Task Force on Transformative Research, and a planning document generated by this task force is currently under review. A key concern of this effort is stimulating interdisciplinarity, that is, transformative research while maintaining the balance with disciplinary research. Ultimately, this issue can only be addressed through continuous feedback between NSF and the scientific community. Maintaining this balance is central to our role as stewards of the U.S. scientific and engineering enterprise.

Let me move on to the matter of how NSF focuses attention to research issues of national importance.

To meet the research challenges that rise to national significance, NSF relies on input from many sources: reports from the National Academies, R&D guidance as presented by the OSTP/OMB priorities memo and the National Science Board, Presidential priorities, such as the American Competitiveness Initiative, Congressional interests, and our extensive interaction with the research community. NSF research priorities are evaluated on a continuous basis by our Advisory Committees, Committees of Visitors, scientific conferences, strategic plans, and so forth.

By funding collaborative grants and cooperative agreements, NSF can foster partnerships with academia and industry, potentially expediting the transition of basic research to products. NSF Center programs engage directly in encouraging industry and university partnerships. But perhaps NSF's most effective partnership with industry is our support of undergraduate and graduate students who enter the private sector armed with the latest understanding of advances in science and engineering fields.

Mr. Chairman, the issues you have raised in this hearing are of profound importance, not only to NSF, but to the Nation. They are not easy matters, nor do they lend themselves to simplistic or formulaic solutions, but I look forward to working with you on these issues and would be pleased to answer any questions you might have.

[The prepared statement of Dr. Bement follows:]

PREPARED STATEMENT OF ARDEN L. BEMENT, JR.

Chairman Baird, Ranking Member Ehlers, thank you for the opportunity to testify before the Research and Science Education Subcommittee today. You have

raised a number of important issues in your invitation letter and I commend you both for taking an active role in promoting a discussion of these questions.

The first issue you raise is in regard to NSF's efforts to nurture young investigators. Encouraging new investigators to become effective contributors to the science and engineering workforce is a critical goal for the National Science Foundation. Supporting young investigators is something that NSF takes seriously and it is an issue that we are addressing in a variety of ways.

Attracting new researchers is a key part of our Learning investment priority, articulated in the NSF's new strategic plan. The Strategic Plan also calls for expanding efforts to broaden participation in all NSF activities and programs. This year NSF is developing a plan to target such opportunities. Assessing the impact of NSF efforts to nurture young investigators, especially at the interfaces between K–12 and university education, two-year and four-year colleges, and technical and other higher education settings will be an important part of the broadening participation plan.

An ongoing program at NSF that supports young investigators is our signature Faculty Early Career Development (CAREER) Program. This is an NSF-wide activity that offers our most prestigious awards in support of the early career-development of young investigators. Successful applicants must effectively integrate research and education within the context of their organization's mission. The longer awards provided through CAREER offer new Principal Investigators (PIs) stability as they build their academic careers. NSF provides 400 CAREER awards annually, each for a duration of five years, to some of the best and brightest graduate students in the country.

Moreover, each year from among these outstanding CAREER awardees, NSF selects nominees for the Presidential Early Career Awards for Scientists and Engineers (PECASE). This Presidential Award is the highest honor bestowed by the U.S. Government on scientists and engineers who are beginning their careers. It is awarded both for excellence in research and for demonstrated leadership and service in their community.

NSF also engages in a variety of outreach efforts intended to assist and nurture young investigators. Our NSF Days program serves to assist investigators in understanding the process of submitting proposals to NSF through workshops that provide an introduction to and overview of NSF, its mission, priorities, budget, and its proposal and merit review process. In the five years that we've had the current configuration of NSF Days we have sponsored 40 workshops that have attracted nearly 6,000 participants. Additional outreach efforts typically pair NSF program officers with researchers whose proposals have been declined in an effort to improve proposals for subsequent re-submission. This is helpful for young investigators as it is the exception rather than the rule that a proposal is accepted by NSF the first time it is submitted. These activities serve to improve the funding rates of young investigators.

The effectiveness of these efforts is shown by the fact that we've maintained the funding rates of young investigators. The current NSF success rate is 21 percent for research grants—a decline from the 30 percent success rate of the late 1990s—however, the percentage of awards made to new investigators as a share of the NSF portfolio has remained stable at 27 percent in 1997 and 28 percent in 2006. Also, the length of time between the year of an investigator's last degree and the year of an investigator's first research grant from NSF in 1997 and 2006 has remained stable. In 1997, 73 percent of new Principal Investigators receiving their first NSF award were within seven years of their last degree and in 2007 the comparable figure was 74 percent.

Still, we continually strive for improvement, and we believe that the variety of programs in place to foster young investigators will continue to increase the pool of successful young investigators involved in the U.S. science and engineering enterprise.

A second item raised in your invitation letter concerned the appropriate balance between interdisciplinary and disciplinary research. The current scientific era is characterized by interdisciplinary research with much of the promise of future work occurring at the interstices between traditional scientific disciplines.

Support for interdisciplinary research is a priority for the National Science Foundation and presents a tremendous opportunity for innovation. And yet the nature of scientific research is changing so rapidly that much of what is today considered disciplinary research would previously have been considered interdisciplinary in nature.

The issue of a balanced portfolio is a pivotal one for NSF. We must continue to push the frontiers through interdisciplinary, transformative research and foster advancements within the scientific and engineering disciplines that serve as a platform for such advancement. We must also balance between individual and small

group research grants, infrastructure awards, center awards, and other types of grants and agreements. Approximately 40 percent of awards go to proposals with two or more PIs, a figure that has more than doubled in the past 20 years. The NSF portfolio is balanced through negotiations between NSF and the National Science Board, through feedback with our many stakeholders—including Congress, the National Academies, OSTP, other research agencies, the research communities—and through the merit review process itself.

NSF's Centers and Priority Areas, as outlined in our budget, serve as catalysts for generating interdisciplinary proposals. These efforts are effective strategic means to cultivate interdisciplinary areas of research. By growing these new avenues of research the participating disciplines are transformed and re-defined.

We have made a deliberate effort to communicate to various scientific communities our interest in supporting interdisciplinary research. Upcoming solicitations are strategically mentioned at all town hall meetings, conferences, workshops, and symposia and we regularly inform the community of interdisciplinary opportunities through Dear Colleague letters.

The use of co-reviews addresses one of the greater challenges that interdisciplinary research proposals present, which is that these proposals frequently require a greater range of expertise among the reviewers than disciplinary proposals. The flexibility of NSF's merit review process allows the program officers to use multiple approaches to meet this challenge for both solicited and unsolicited interdisciplinary proposals. The program officers will often work collaboratively, sharing their expertise to identify the right reviewers and to assess the reviewers' input. In some cases, mail reviews can be used to provide deeper expertise on various aspects of the proposal. Panel reviews are often used to integrate reviews from different disciplinary perspectives, and provide a broader interdisciplinary overview.

Recognizing which proposals are interdisciplinary poses little difficulty, especially when they are submitted in response to a specific solicitation. As for the unsolicited interdisciplinary research proposals, FastLane gives PIs an opportunity to select multiple programs as potential units to consider the proposal. Program officers take note when multiple programs are listed, and will evaluate if the interdisciplinary nature of the proposal is such that co-reviews by more than one program are warranted. Even if the PI does not choose multiple programs for review, program officers can recognize interdisciplinary proposals, and will bring these proposals to the attention of their colleagues in the appropriate programs. Co-reviews can be arranged between the relevant program officers on a case-by-case basis or on a larger scale if appropriate. For example, in the last few years program officers in BIO and MPS have recognized the increasing interdisciplinary nature of the research being proposed by new investigators and have coordinated the co-review of CAREER proposals that lie at the interface of the biological and physical sciences.

In 2004, the National Science Board initiated a Task Force on Transformative Research. A planning document generated by this task force is currently under review. A key concern of this effort is stimulating interdisciplinary, transformative research while maintaining the balance with disciplinary research. One aspect of the NSF internal task group on the Impact of Proposals and Award Management Mechanisms (IPAMM) study is taking a closer look at transformative research. Ultimately, this issue can only be addressed through continuous feedback between NSF and the scientific community, and it is an issue that is central to our role as stewards of the U.S. scientific and engineering enterprise.

Let me move on to the matter of how NSF focuses attention to research issues of national importance. NSF is committed to fostering the fundamental research that delivers new knowledge to meet national needs and to improve the quality of life for all Americans. To meet the challenges of concern to our nation, NSF research activities are determined in accordance with guidance from several sources. These include reports from the National Academy of Sciences, R&D guidance as presented by the OSTP/OMB priorities memo, Presidential priorities such as the American Competitiveness Initiative, congressional interests, and the research community. NSF research priorities are evaluated on a continuous basis through such activities as Advisory Committees, Committees of Visitors, scientific conferences, strategic plans, etc. The priorities that emerge reflect the current needs of the Nation and are updated and represented annually in the Budget Requests to Congress.

Through funding collaborative grants and cooperative agreements, NSF can foster partnerships with academia and industry, potentially expediting the transition of basic research to "products." Several NSF programs are directly related to encouraging industry and university partnerships such as Small Business Innovative Research/Small Business Technology Transfer Research; Partnerships for Innovation and many of our Centers programs (e.g., Engineering Research Centers; Industry/University Cooperative Research Centers; Science and Technology Centers; Mate-

rials Research Science and Engineering Centers; and Nanoscale Science and Engineering Centers). NSF's most effective partnership with industry is accomplished through training undergraduate and graduate students who in turn enter the private sector with advanced skills in science and engineering fields.

NSF's Broader Impacts criterion requires each proposal to address the question "What are the broader impacts of the proposed activity?" This is an excellent way of determining whether proposals meet the mission of NSF, and therefore meets the needs of the Nation. Considerations embedded in this criterion reflect the need to promote teaching and training among all citizens.

Mr. Chairman, the issues you have raised in this hearing are of profound importance, not only to NSF, but to the Nation. They are not easy matters, nor do they lend themselves to simplistic or formulaic solutions. I commend you for making these matters the topic of your first hearing as Chairman and I look forward to responding to any questions the Members of the Committee may have.

BIOGRAPHY FOR ARDEN L. BEMENT, JR.

Arden L. Bement, Jr., became Director of the National Science Foundation on November 24, 2004. He had been Acting Director since February 22, 2004.

He joined NSF from the National Institute of Standards and Technology, where he had been director since Dec. 7, 2001. As head of NIST, he oversaw an agency with an annual budget of about $773 million and an on-site research and administrative staff of about 3,000, complemented by a NIST-sponsored network of 2,000 locally managed manufacturing and business specialists serving smaller manufacturers across the United States. Prior to his appointment as NIST Director, Bement served as the David A. Ross Distinguished Professor of Nuclear Engineering and head of the School of Nuclear Engineering at Purdue University. He has held appointments at Purdue University in the schools of Nuclear Engineering, Materials Engineering, and Electrical and Computer Engineering, as well as a courtesy appointment in the Krannert School of Management. He was Director of the Midwest Superconductivity Consortium and the Consortium for the Intelligent Management of the Electrical Power Grid.

Bement came to the position as NIST director having previously served as head of that agency's Visiting Committee on Advanced Technology, the agency's primary private-sector policy adviser; as head of the advisory committee for NIST's Advanced Technology Program; and on the Board of Overseers for the Malcolm Baldrige National Quality Award.

Along with his NIST advisory roles, Bement served as a member of the U.S. National Science Board from 1989 to 1995. The board guides NSF activities and also serves as a policy advisory body to the President and Congress. As NSF Director, Bement now serves as an ex officio member of the NSB.

He currently serves as a member of the U.S. National Commission for UNESCO and serves as the Vice-Chair of the Commission's Natural Sciences and Engineering Committee.

Bement joined the Purdue faculty in 1992 after a 39-year career in industry, government, and academia. These positions included: Vice President of Technical Resources and of Science and Technology for TRW Inc. (1980–1992); Deputy Under Secretary of Defense for Research and Engineering (1979–1980); Director, Office of Materials Science, DARPA (1976–1979); Professor of Nuclear Materials, MIT (1970–1976); Manager, Fuels and Materials Department and the Metallurgy Research Department, Battelle Northwest Laboratories (1965–1970); and Senior Research Associate, General Electric Co. (1954–1965).

He has been a Director of Keithley Instruments Inc. and the Lord Corp. and was a member of the Science and Technology Advisory Committee for the Howmet Corp. (a division of ALCOA).

Bement holds an engineer of metallurgy degree from the Colorado School of Mines, a Master's degree in metallurgical engineering from the University of Idaho, a doctorate degree in metallurgical engineering from the University of Michigan, an honorary doctorate degree in engineering from Cleveland State University, an honorary doctorate degree in science from Case Western Reserve University, an honorary doctorate degree in engineering from the Colorado School of Mines, and a Chinese Academy of Sciences Graduate School Honorary Professorship. He is a member of the U.S. National Academy of Engineering and a fellow of the American Academy of Arts and Sciences.

Chairman BAIRD. Thank you, Dr. Bement. And I am painfully aware that for something as complicated as NSF and the related

Board, a five-minute introductory statement is not nearly enough, but please rest assured we will give you plenty of time through the Q&A to elaborate on some of the very, very salient points you made.

Dr. BEMENT. Thank you.

Chairman BAIRD. Dr. Beering.

STATEMENT OF DR. STEVEN C. BEERING, CHAIRMAN, NATIONAL SCIENCE BOARD

Dr. BEERING. Chairman Baird, Ranking Member Ehlers, and Members of the Subcommittee. I appreciate the opportunity to appear before you. I am the President Emeritus of Purdue University, and I am privileged to be here with Arden Bement, with whom I have worked for the past 15 years, both at Purdue and at the National Science Foundation.

This is my first time to testify before you as Chairman of the National Science Board, a position to which I was elected in May 2006, and I am, indeed, honored to be with you.

Congress established the National Science Board in 1950 and gave it dual responsibilities: to guide the activities of and establish the policies for the National Science Foundation, and to serve as an independent advisory body to the President and the Congress on national policy issues related to science and engineering research and education.

On behalf of the entire Board and the widespread and diverse research and education communities that we all serve, I thank the Members of this subcommittee for your long-term support of a broad portfolio of investments in science, technology, engineering, and mathematics research and education. Your continuing bipartisan commitment to excellence in U.S. science and engineering research and education has ensured that the United States remains the leader in global innovation and discovery.

My complete written testimony has already been submitted to you for the record.

Let me now briefly address the questions Chairman Baird raised in his letter of March 7.

First, what can NSF do to nurture young investigators and to improve their funding rates? This was a major and ongoing concern for the Board. In our December 2003 report to Congress that responded to Section 22 of the last NSF Authorization Act, we identified the need of an additional $1 billion over the five-year period of 2002 to 2007 to fund more grants generally and $200 million to fund an expansion of the institutions of higher education participating in NSF activities, including funding for start-up awards to new Ph.D.s at those institutions.

New Ph.D.s just starting their academic careers, no matter how excellent their academic record, are less likely to be employed by top-tier institutions and more likely to start their careers in primarily teaching situations. Expanding research in these institutions, therefore, opens doors for new Ph.D.s to build careers in research.

We also support the expansion of the NSF CAREER Faculty Early Career and similar programs coupled with general expansion of funding for basic research, also called for by the American Com-

petitiveness Initiative and the National Academies' report *"Rising Above the Gathering Storm."*

The NSF authorization of 2002 included a welcome authority to double the budget over a five-year period to nearly $10 billion in 2007. The actual 2007 budget of approximately $6 billion represents a significant gap with the 2002 authorization. The American Competitiveness Initiative again calls for a doubling of the NSF budget over a 10-year period. We would respectfully suggest that the time to implement these admirable authorizations and initiatives has never been more urgent than now.

Your second series of questions regarding NSF funding for interdisciplinary research focused on the appropriate balance between funding for interdisciplinary and disciplinary research, best mechanisms for soliciting and funding interdisciplinary research proposals, and the sufficiency of publicizing interdisciplinary research funding opportunities at NSF. This is another area to which NSF and the Board have given considerable attention of resources. Nonetheless, there remains substantial issues to assure that interdisciplinary research is not disadvantaged in the highly-competitive NSF merit review system or in the academic sector by structural impediments.

NSF has taken a number of steps over a long period of time to ensure that the level of investment and mechanisms of support address structural roadblocks to funding interdisciplinary research. For example, NSF supports nearly 100 centers in part to provide greater opportunities for, and encourage, interdisciplinary research. The most recent Board guidance to NSF on balance between centers and individual investigator awards establishes a six to eight percent of the R&RA budget as an appropriate level to support centers.

With respect to publicizing opportunities for interdisciplinary research, I should point out that most research proposals submitted to NSF are unsolicited, and that is a good thing for the health of U.S. research. To a great extent, this enables the research community to self-identify and establish a balance between disciplinary and interdisciplinary work on the basis of opportunities for discovery and the quality of the research proposals submitted. However, it is also important to ensure that researchers are knowledgeable about all NSF funding opportunities and the process for obtaining that funding, and further, that the review process is fair and results in the best use of scarce funding to fund cutting-edge research.

You also asked about the NSF role in research driven by national needs and fostering university-industry partnerships and the application of Criterion 2, which encourages partnerships of the NSF merit review process with regard to national needs.

NSF's mission is defined in the NSF Act in terms of national needs, and such needs, both broadly and narrowly defined, have always shaped the portfolio of our investments. The Board established Criterion 2 of the merit review system in part to enhance partnerships, potential benefits to society, and contributions to innovation. Further, NSF has long participated in interagency R&D priorities, most recently including the National Nanotechnology

Initiative, Climate Change Science program, Networking and Information Technology R&D, and Homeland Security.

Moreover, NSF Center programs often explicitly require partnering with industry. In addition, NSF funds small business innovation research and cross-agency and cross-sectoral research programs in such areas as earthquake science and engineering and research in the Polar Regions.

The Board has also recently published a report recommending a new national Hurricane Research Initiative that cuts across fields of science, suggests a co-lead role for NSF and NOAA, and includes a number of additional agencies as major players.

Your final question concerns NSF's priorities in K–16 science, technology, engineering, and mathematics, so-called STEM education, and how the current budget reflects those priorities, especially NSF's role in undergraduate education.

The Board has been especially concerned with this major area of NSF's responsibility: education in science, technology, engineering, and math. Education is the core mission of NSF. Even while U.S. student performance in mathematics and science is declining relatively as assessed internationally, changing the workforce requirements means that new workers will need ever more sophisticated skills in STEM disciplines.

Following a request from Congress, the Board established a new advisory commission on 21st century education in science, technology, engineering, and mathematics in March of 2006, comprising a wide range of eminent experts, representing the broad scope of interests in U.S. STEM education. We have charged that commission to examine and advise us on the role of NSF in both pre-college and undergraduate education as part of its activities. Moreover, the Board is expecting shortly to receive the report of our Education and Human Resources Committee on Engineering Education Reform primarily at the undergraduate level.

We expect that, following our Board meeting next week, when we will receive advice from our STEM education commission, and over the next few months with the work of the Board's Education and Human Resources Committee evaluating assessments of NSF education programs, we will develop new guidance to the Foundation on its priorities for education programs at the undergraduate and pre-college levels.

Following our Board meeting next week, we would welcome the opportunity to meet with individual Members of your Committee, and others in the Congress and the Administration, to discuss the Board's national action plan for addressing our nation's STEM education needs.

The federal investment in the Nation's science and technology is a necessity for our future prosperity and security. To quote a recent editorial by Microsoft founder, Bill Gates, in the *Washington Post,* "If the United States is to remain a global economic leader, we must foster an environment that enables the new generation to dream up innovations." As other nations ramp up their investment of the infrastructure for research and innovation, we cannot be complacent.

I have just returned this past week from the European Union's Congress, and I am absolutely impressed and astounded at the

progress of those 27 nations. We must sustain the advantages that we have gained through continued wise, adequate federal support for our science and engineering research and education enterprise. The National Science Foundation is a key asset to our nation, having proven itself effective in stimulating discovery and innovation for now over half a century, working in partnership with the research and higher education communities.

The Board is committed to working with you to assure that limited federal funding resources are optimally invested through the National Science Foundation to sustain U.S. leadership in science and technology.

Thank you very much.

[The prepared statement of Dr. Beering follows:]

PREPARED STATEMENT OF STEVEN C. BEERING

Chairman Baird, Ranking Member Ehlers, and Members of the Subcommittee, I appreciate the opportunity to testify before you. I am Steven Beering, President Emeritus of Purdue University, West Lafayette, Indiana and Chairman of the National Science Board (Board). This is my first time testifying before you as Chairman of the Board, a position to which I was elected in May 2006. I am honored to represent the National Science Board before you today.

Since the Board last testified before this subcommittee, there have been many changes—both in Congress and on the Board. Nine of our 24 Board Members rotated off the Board in 2006 and nine new Board Members have been appointed by the President and confirmed by the Senate. Board members are selected so as to broadly represent the leadership of U.S. science and engineering research and education.

In addition to my being elected as the new Board Chairman, the Board also elected a new Vice-Chairman, Dr. Kathryn Sullivan, Director, Batelle Center for Mathematics and Science Education Policy, John Glenn School of Public Affairs, Ohio State University, Columbus. I have appointed Dr. Kenneth Ford, Director and Chief Executive Officer, Institute for Human and Machine Cognition, Florida, to lead our Committee on Programs and Plans; Dr. Dan Arvizu, Director and Chief Executive of the National Renewable Energy Laboratory (NREL), Colorado, as Chairman of our Committee on Audit and Oversight; Dr. Ray Bowen, President Emeritus of Texas A&M University to lead our Committee on Strategy and Budget; and Dr. Elizabeth Hoffman, Executive Vice President and Provost Iowa State University, Ames, as Chairman for the Committee on Education and Human Resources.

Congress established the National Science Board in 1950 and gave it dual responsibilities:

- Oversee the activities of, and establish the policies for, the National Science Foundation (the Foundation, NSF); and
- Serve as an independent advisory body to the President and the Congress on national policy issues related to science and engineering (S&E) research and education.

On behalf of the entire Board and the widespread and diverse research and education communities that we all serve, I thank the Members of this subcommittee for your long-term commitment to a broad portfolio of investments in science, technology, engineering, and mathematics (STEM) research and education. While it is critical that our nation significantly increase our support for this portfolio, it is also important that these investments be diverse and balanced. The Board greatly appreciates long-term Congressional support of the Board, the Foundation, and their programs and activities. Your continuing bipartisan commitment to excellence in U.S. science and engineering research and education has ensured that the U.S. remains a world leader in the global innovation and discovery enterprise. As you all are well aware, continued investment is required for the U.S. to maintain a global leadership position in science and technology.

I will turn now to answer the specifics questions you presented to me, Mr. Chairman, in your letter of March 7, 2007. Following these responses, I will provide a brief overview of Board activities over the last year, forecast activities for the coming year, and then provide you with some specific issues you may wish to consider for inclusion in the re-authorization language.

QUESTIONS FROM CHAIRMAN BAIRD

Your questions focus on a number of challenging issues that are subject to continual consideration and discussion by the Board, as they are central to fulfilling NSF's mission in research and education under the *NSF Act of 1950* (as amended). That mission is to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense.

QUESTION 1: What can NSF do to nurture young investigators and to improve their funding rates?

The Board has consistently expressed our concern that research funding nurture new researchers and sustain excellent researchers throughout their careers. For instance, a National Science Board policy, endorsed in 1977 and amended in 1984, requests that the NSF Director submit an annual report on the NSF merit review process. This report allows us to monitor the funding rates for new principal investigators (PIs) annually. The *FY 2006 Report on the NSF Merit Review Process* [(NSB–07–22) *http://www.nsf.ogv/nsb/documents/2007/merit_review.pdf,* available March 30, 2007] indicates that 18,061 proposals were received from new PIs during FY 2006, of which 18 percent were funded. New PIs are defined as those who have not previously been awarded an NSF grant, and are generally regarded as professionally "young" investigators (less than five years from attaining degree). Grant proposal success rate overall is 25 percent, with a 30 percent rate for PIs who received prior awards (prior PIs). The funding rate of new PIs has been two-thirds or less of prior PIs, since 1999. Additional funding for Research and Related Activities (R&RA) under the 2008 request is welcome, to the extent that it can increase the funding rate for grants, so that these gifted new researchers will not become discouraged and leave their careers in research.

As directed by Congress in Section 22 of the Foundation's 2002 Authorization Act, the Board prepared a report, *Fulfilling the Promise* [(NSB–03–151) *www.nsf.gov/nsb/documents/2003/nsb03151],* to outline how additional funding would be spent in the event the NSF budget were doubled over a five-year period. This report also identifies the need for $1 billion over the five-year period to fund more grants, and $0.2 billion to expand the institutions of higher education participating in NSF activities, including funding for start-up awards to new Ph.D.s. The Board supports expansion of the NSF CAREER (faculty early career, *www.nsf.gov/funding/pgm_summ.jsp?pims_id=5262*) program, as long as such expansion is funded through additional appropriations, so as not to undercut the Board priority for NSF to also increase the size and duration of awards and increasing funding for novel ideas and approaches.

The Board applauds the recommendations for research in the *American Competitiveness Act,* reflecting the National Academies report, *Rising Above the Gathering Storm (www.nap.edu/catalog.php?record_id=11463),* to increase federal investment in long-term basic research by 10 percent each year over the next seven years; and to double the NSF budget in 10 years. We also strongly supported the existing congressionally authorized doubling of the NSF budget to approximately $10 billion over the five-year period FY 2003 to FY 2007, under the 2002 NSF Authorization. Nevertheless, current funding for NSF falls well short of authorized levels. We would respectfully suggest that the time to implement these admirable authorizations and initiatives through actual appropriations has never been more urgent than now.

We further applaud the additional support appropriated in recent years to physical sciences, engineering, mathematics and computer sciences, which were identified for attention in the Board's 2003 report, *The Science and Engineering Workforce/Realizing America's Potential* [(NSB–03–69) *www.nsf.gov/nsb/documents/2003/nsb0369.pdf].* However we caution that increased funding for one area should not be at the expense of other parts of the NSF portfolio that also offer expanding opportunities for discovery, such as the biological sciences at NSF, which have been funded now for a decade below the level of increase of the portfolio as a whole.

QUESTION 2: What is the appropriate balance between funding for interdisciplinary and disciplinary research? What are the best mechanisms for soliciting and funding interdisciplinary research proposals? Is NSF doing a sufficient job of publicizing opportunities for funding of interdisciplinary proposals?

The Board has a long-standing commitment to support for interdisciplinary research. In a 1988 report, *Report of the National Science Board Committee on Centers and Individual Investigator Awards* (NSB–88–35) the Board noted that the use of centers was increasing because centers epitomize the growing complexity, cost, and

organization of modern research. The rationale for support for centers was based in large part on their interdisciplinary nature to exploit opportunities in science where the complexity of the research problem can benefit from the sustained interaction among disciplines and/or sub-disciplines, and to stimulate new directions and styles of inquiry in research including collaborative, cross disciplinary, and interdisciplinary approaches.

In the early 1990s, the Board sponsored a review, with the National Academies' Government-University-Industry Research Roundtable, of emerging stresses in the university community [*Stresses on Research and Education at Colleges and Universities: Institutional and Sponsoring Agency Responses* (July 1994)]. Interdisciplinary research was identified as a key issue. Among the concerns were a greater difficulty in assembling and sustaining interdisciplinary teams and the perceived reduced probability for success due to the likelihood that reviewers of an interdisciplinary proposal would not be expert in all areas covered, and therefore be unlikely to rate fairly an interdisciplinary proposal.

Understanding the important role of individual investigator grants to the U.S. basic research enterprise, and that these types of grants are vital sources of interdisciplinary research, the Board issued guidance (NSB–05–166, Appendix C to NSB–05–166) in December 2005 to NSF on the relative balance of funding for centers, stating that "NSF's investment in centers should be reported as both a percentage of the R&RA account and as a percentage of the total NSF budget, with the range of support for NSF centers being six to eight percent of R&RA. However it is important to consider that the relative balance of funding for principal investigators, large facilities, and centers will vary considerably across disciplines."

The Foundation funded nearly a hundred centers in FY 2006. These centers allow groups of scientists and engineers to address broad scientific and engineering challenges that are of interest to the general public, and to encourage innovation. They are typically interdisciplinary in character and provide opportunities for partnering across institutions, agencies and sectors, and internationally. In addition to centers, the Foundation supports a number of cross disciplinary priority areas that include collaborations across disciplines and agencies to address national research and development (R&D) priorities—currently in nanotechnology, climate change science, networking and information technology, and homeland security.

NSF also supports interdisciplinary proposals through less formal means through collaborations across programs and directorates within the agency. When program officers present their portfolio of proposed awards for review, they must explain what makes the projects exciting, high risk and/or multi-disciplinary. Identifying the most innovative proposals is an explicit part of program officers' responsibilities. Several mechanisms are built into the oversight process to ensure that multi-disciplinary proposals are on a fair footing with other proposals in the merit review process, including each program's Committee of Visitors (COV) and NSF's Advisory Committee for GPRA Performance Assessment (AC/GPA).

It is important for the merit review process generally, and for interdisciplinary or multi-disciplinary proposals in particular, that the process employed for merit review be clearly explained and understood, both by reviewers and program officers and by applicants. Identifying the most innovative and multi-disciplinary proposals is an explicit program officer responsibility, but these concepts are difficult to define for the proposal review context. In response to concerns about the uncertainty of what constitutes "multi-disciplinary," NSF is now collecting explanations of projects that program officers identify as multi-disciplinary. Clarity in these identifications should result in an improved ability to communicate with the research communities, which should result in more effective outreach.

A large share of NSF proposals is unsolicited. This factor is important in allowing the community to provide grass roots input to identify the most promising areas for discovery, whether disciplinary or interdisciplinary in nature. The correct "balance" at any one time would be difficult to fix in advance. For example, the provision of a new instrument for science or a new discovery that shifts a traditional paradigm would be likely to stimulate new ideas and proposals within the affected scientific research areas. Perhaps subsequent proposals stimulated by this new impetus would be either interdisciplinary or disciplinary proposals, depending on the nature of the change, which might affect the balance between meritorious interdisciplinary and disciplinary proposals received by particular programs for consideration. In short, the right balance at any time is determined by the opportunities for discovery and the quality of the proposals submitted.

The Board has requested that NSF conduct a review of the impacts of NSF proposal and award management mechanisms. With the information provided from this review, the Board will be better positioned to provide guidance and establish appro-

priate policy for NSF program portfolio balance across disciplines, to include interdisciplinary research.

QUESTION 4: NSF, unlike the mission oriented science agencies, is a mainly proposal-driven agency. However, there are significant issues of concern to our nation—competitiveness, security, energy—that can be addressed, at least in part, through technology enabled by solutions or answers to known scientific challenges and questions.

What is the appropriate role for NSF in such research driven by national needs? In fostering industry/university partnerships? Is this a valid application of Criterion 2 of NSF's merit review process?

The Foundation was established to serve national needs including promoting the progress of science, advancing the national health, prosperity, and welfare, securing the national defense, and other purposes. National needs, both broadly and more narrowly defined, have always shaped the portfolio of NSF investments, and these investments should continue to address our nation's needs as they evolve. Criterion 2 includes enhancements to partnerships, and potential benefits to society, and therefore includes contributions to innovation. Although NSF does not directly support technology development or deployment, the research it funds is driven by important national needs, and indeed NSF participates in interagency R&D priorities including the National Nanotechnology Initiative, Climate Change Science Program, Networking and Information Technology R&D, and Homeland Security for the last several years.

One example of NSF participation in cross agency activities to benefit society is membership in the National Science and Technology Council's Subcommittee on Disaster Reduction (SDR) and of the legislatively-created National Earthquake Hazards Reduction Program (NEHRP). NSF's principal contribution to NEHRP is the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), an impressive collection of 15 large-scale experimental sites that feature advanced tools linked to a centralized data pool and earthquake simulation software, all of which is bridged together by the high-speed Internet2.

One of the NEES sites is the O.H. Hinsdale Wave Research Laboratory at Oregon State University, which the Board recently visited. Research from Hinsdale and the other NEES facilities will help to advance our understanding and improve seismic performance of civil infrastructure in the U.S. and around the world and will lead to the design of buildings and development of building construction techniques to reduce the potential for damage to structures from tsunamis and other earthquake-related disasters.

Recently, the National Science Board issued its report *Hurricane Warning: The Critical Need for a National Hurricane Research Initiative* [(NSB–06–115) *www.nsf.gov/nsb/committees/hurricane/initiative.pdf*], recommending the role of NSF and operational agencies like NOAA, NIST, NASA, USDA, and the Navy in the creation of a substantial new federal science and engineering enterprise for benefiting society. This enterprise would undertake a focused, sustained, and multi-agency initiative to improve our understanding of, and ability to predict, mitigate, and respond to, the impacts of hurricanes on the population, the built-infrastructure, and the natural environment.

Another example of meeting national needs is the Foundation's involvement with energy research as a partner in the President's hydrogen fuel initiative through membership in the Interagency Hydrogen and Fuel Cell Technical Task Force. Related to this is the NSF's Energy for Sustainability Program, which will fund basic research and engineering of hydrogen and other alternative fuel systems, and the U.S. Climate Change Technology Program to develop the basic understanding that will facilitate the development of new and advanced technologies to address climate change.

NSF advances national competitiveness through its many educational programs from the grade school to post graduate levels, and by providing essential research infrastructure through its four multi-user Federally-Funded Research and Development Centers, the construction of Major Research Equipment and Facilities, and through its eight Centers programs. The National Science Board's "Science and Engineering Indicators" and the NSF's surveys and reports provide statistics reflecting the condition of important components of U.S. and global science and technology, and provide information to track national competitiveness in science and engineering and to inform future programs to further promote competitiveness.

NSF also helps to promote innovation through individual researchers. For example, Phase I recipients of the Foundation's Small Business Innovation Research Awards (SBIR) are invited to participate in NSF-sponsored business development programs. These programs help our awardees understand the issues associated with technology development and deployment that may be outside the experience of research scientists. NSF has found that these programs significantly increase the quality of commercialization plans and as a result the success rate of advancing to Phase II SBIR funding. Eleven federal agencies fund research through an SBIR program, but NSF is the only one to offer the entrepreneurial training to Phase I funding recipients.

While technology development and deployment are not the direct objectives of the National Science Foundation, the data show our grantees have been successful in combining NSF support with funding from industry and other federal agencies and their own ingenuity to develop useful inventions. For example, 272 United States Patents were granted in 2006 that have acknowledged funding from the National Science Foundation. Analysis of these patents also reveals how NSF funding helps to further the research of the 'mission' agencies. Research for over 44 percent of NSF-related patents in 2006 were co-sponsored by one or more of the 'mission' agencies, including USDA, NIH, NASA, and the Departments of Defense, Education, and Energy. In addition, researchers filed 379 U.S. Patent applications in 2005 for inventions sponsored, at least in part, by NSF. For each the past three calendar years, NSF awardees have disclosed over 1000 inventions. In fact, the "iEdison.gov" database reports NSF is consistently one of the top two federal agencies in terms of the number of inventions disclosed by researchers it supports.

Moreover, since CY 2004, NSF has directly funded fundamental research to enhance homeland security. In FY 2006, NSF funding in this area was $342 million and it has requested $375 million in FY 2008, to fund research in such areas as information security, understanding vulnerabilities and strengthening U.S. critical infrastructure, and automated understanding of language.

QUESTION 5: What are NSF's priorities in K–16 science, technology, engineering and mathematics (STEM) education? How does the current budget reflect those priorities? In particular, what is NSF's role in supporting undergraduate STEM education?

The Board has been especially concerned with a major area of NSF responsibility—education in science, technology, engineering and mathematics (STEM). Education is a core mission of NSF, which not only includes advanced education in connection with funded research, but also responsibility for promoting quality math and science education as intertwining objectives at all levels of education across the United States. NSF's highly competitive peer-review process is second to none for openly and objectively identifying, reviewing, selecting, funding and providing stewardship for the very best STEM proposals and programs in research and education.

The Board has a long-term concern with the condition of STEM education at all levels of the system. Nearly a quarter century ago, the National Science Board's Commission on Pre-college Education in Mathematics, Science and Technology assessed the state of U.S. pre-college education in the subject fields and found it wanting. At the same time, in 1983 the U.S. Department of Education's National Commission on Excellence in Education published the report, *A Nation At Risk (www.ed.gov/pubs/NatAtRisk/risk.html).* This document stated: "By the year 2000, U.S. students will be the first in the world in mathematics and science achievement," expressing alarm on the "rising tide of mediocrity [in education] that threatens our very future as a Nation and a people." Despite these two reports—*A Nation At Risk* sounding the alarm and the Board's Commission report recommending solutions—and many others since then, we continue to slip further behind. Not only are they not first, but by the time they reach their senior year, even the most advanced U.S. students perform at or near the bottom on international assessments. There is now an even more pressing need to build a new foundation for U.S. STEM education.

The Board has explored in a number of policy reports how the Foundation and other components of the STEM education system in this country can be more effective. Even while U.S. student relative performance in mathematics and science is declining on international assessments, changing workforce requirements mean that new workers will need ever more sophisticated skills in STEM disciplines. This emerging workforce, consisting of degreed and highly skilled technical workers, will need to begin developing their mathematical and science skills early in their educational career. In addition, the rapid advances in technology in all fields mean that even those students who do not pursue professional occupations in technological

fields will also require solid foundations in science and math in order to be productive and capable members of our nation's society.

As some of you know, the Board established a second Commission on STEM education—the Commission on 21st Century Education in Science, Technology, Engineering and Mathematics in March 2006, comprising a wide range of eminent experts representing the broad scope of interests in U.S. STEM education *(www.nsf.gov/nsb/edu_com).* We have held a number of hearings across the country—both in the process of considering the charge to such a Commission, and subsequently during several meetings of the new Commission. Science and Technology Committee Chairman Gordon and Vice Chairman Lipinski, and several other Members of the Subcommittee on Research and Science Education—Ranking Member Ehlers and Congresswoman Johnson, and other Members of Congress, including Speaker Pelosi, Congressman Mark Udall, Congressman Wolf and Congressman Culberson, as well as former Science Committee Chairman Boehlert, have attended one of these hearings or otherwise contributed their insights to this process. We look forward to receiving the draft action plan to reform U.S. STEM education from the Commission for discussion at the March 2007 National Science Board meeting. The plan will include STEM education from pre-K through college and beyond, and specific recommendations on the NSF role in STEM education reform at all levels.

The Board has expressed our support for the NSF role in improving the linkage between the K–12 and higher education systems both in the charge to our Commission on 21st Century Education in STEM, and in our 2004 Statement in Support of the NSF Mathematics and Science Partnerships (MSPs) *(www.nsf.gov/nsb/documents/2004/nsb_msp_statement2.pdf)* funded through the NSF Education and Human Resources budget. We are pleased that the MSP experiments are beginning to show early positive results. In part, the NSF MSP Program provides for the collaboration between pre-college and college to promote excellence in teaching and learning, therefore facilitating the transitions for students from kindergarten through the baccalaureate in STEM disciplines. The added benefit for our nation is those students who do not choose STEM careers become the informed scientifically literate voting citizens we need for the 21st Century. Recent assessment data on MSP projects indicate this program has been effective in increasing student performance at all levels assessed—elementary, middle and high school *(http://www.nsf.gov/news),* and promoting collaboration between pre-college and higher education. Therefore, we are pleased that the NSF budget request for FY 2008 will permit funding of new starts in the NSF/MSP program. However, it is again incumbent on the Board to note that the FY 2008 request for NSF EHR remains approximately 10 percent below the FY 2004 level *(not corrected for inflation)* of funding for this portfolio.

The vertical integration of STEM education from pre-kindergarten through graduate school has also been one of the primary foci of the Board's Commission, and we expect to receive valuable guidance from their report on how the Foundation can contribute to such vertical integration in its programs at the undergraduate, pre-college and advanced levels of STEM education. The Board also has been undertaking, through its Committee on Education and Human Resources, an examination of the NSF EHR Directorate's programs with respect to evaluation procedures and results over the last year. The Board feels strongly that NSF EHR programs not only must be effective in relatively short-term evaluations of their success in achieving desired outcomes of individual programs, but that, in combination, these programs must be effective in addressing U.S. long-term needs to retain its essential global advantage in S&E human resources. We have submitted an initial report on our review to Congress at the request of Congressman Rush Holt, and we will be continuing to apprise you about that review as we take into account the recommendations of the Board's STEM Education Commission, the report of the Academic Competitiveness Council, and the plans for the NSF EHR Directorate under its new leadership.

OVERVIEW OF NSB ACTIVITIES DURING THE LAST YEAR

Now I would like to update you on National Science Board activities over the last year and some of our priorities for the coming year in both a) NSF policy-setting and oversight, and b) advising the President and Congress, our dual responsibilities.

NSF Oversight and Policy Direction

During the last year, the Board accomplished a great deal in terms of its mission to provide oversight and policy direction to the Foundation, including: reviewed and endorsed the OIG Semi-annual Reports to Congress and approved NSF management responses; approved the NSF FY 2008 Budget Submission for transmittal to OMB; approved the Foundation's annual Merit Review Report; and provided review and

decisions on major awards or proposal funding requests, including awards totaling $616 million. These awards will support advanced research, science education, and public understanding of critical issues facing our nation. The Board also approved a new strategic plan for NSF *Investing in America's Future: Strategic Plan FY 2006–2011* [(NSF–06–48) *www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf0648*], based on the *National Science Board 2020 Vision for the National Science Foundation* report [(NSB–05–142) *www.nsf.gov/pubs/2006/nsb05142/nsb05142.pdf*] to Congress. In addition, the Board accepted the Foundation's 2007 *Facility Plan* (NSF–07–22) and the Plan was released in conjunction with the President's budget in February 2007. The Facility Plan was mandated by a joint management report of the Foundation and the Board, *Setting Priorities for Large Research Projects Supported by the National Science Foundation* [(NSB–05–77) *www.nsf.gov/pubs/2005/nsb0577/index.jsp*].

The Board has just released our draft report, *Enhancing Support of Transformative Research at the National Science Foundation* (*http://www.nsf.gov/nsb/documents/2007/tr_draft.pdf*) for public comment and review. The Board states in this draft report that we believe it is unreasonable to expect that small adjustments to NSF's existing programs and processes will overcome the perception among much of the external scientific community that iconoclastic ideas are not welcome at NSF. System-wide changes for this purpose are also inappropriate. As noted in the *Report of the National Science Board on the National Science Foundation's Merit Review System* (NSB–05–119) *www.nsf.gov/nsb/documents/2005/0930/merit_review.pdf*], NSF's current merit-review system is functioning effectively to support the excellent innovative research that is significantly advancing the frontiers of knowledge and the goals of our nation. Nonetheless, our nation cannot afford to miss opportunities, discoveries, and new frontiers that can result from bold, unfettered exploration and freedom of thought that challenges our current understanding of natural processes. The NSF cannot allow the perception by any of the Nation's scientists that it does not welcome or support innovative ideas and potentially transformative research. Public support of and careful investment in paradigm-challenging ideas are critical not only to continued economic growth, but also to the future welfare of our nation. In this draft report, therefore, the Board recommends that NSF develop a distinct, Foundation-wide Transformative Research Initiative distinguishable by its potential impact on prevailing paradigms and by the potential to create new fields of science, to develop new technologies, and to open new frontiers. Foundation management will report back to the Board at its August 2007 meeting on its preliminary plan for a simple and transparent process for instituting the Transformative Research Initiative that encourages maximum participation by the community.

In a constrained budget environment, achieving the reasonable balance of award size, and duration, and proposal success rate at the Foundation is an important concern of the Board. We have held several discussions with Foundation management about this issue and are anticipating a comprehensive report later this year that will inform us in establishing appropriate policy guidelines.

A very high priority for the Board has been our continuing work with the NSF Management and the Office of Inspector General to resolve the correction of the existing reportable conditions that have been longstanding in NSF annual audits. We have reviewed the draft Corrective Action Plan for Reportable Conditions in the FY 2006 Financial Statement Audit and are confident that we can quickly and effectively resolve outstanding issues. NSF management will report to the Board at our March meeting on the status of their efforts to resolve the reportable conditions, as well as efforts to enhance NSF's business model practices and develop a strategic personnel workforce plan for the 21st. Century.

Advice to the President and Congress

The Board has undertaken a wide range of activities this year, in our broader role as an independent advisory body to the President and the Congress on national policy issues related to science and engineering (S&E) research and education.

- The Board completed a series of public hearings, in response to a Congressional request that the Board consider reconstituting its 1982 Commission on Pre-college Education in Science, Mathematics, Engineering and Technology, and in March 2006 approved the establishment of the new Commission on 21st Century Education in STEM, due to present its draft report to the Board in March 2007;
- The Board published and disseminated an important report, *HURRICANE WARNING: The Critical Need for a National Hurricane Research Initiative* (NSB–06–115). The report presents an agenda for action that will provide urgently needed hurricane science and engineering research and education that

engages relevant agencies across the Federal Government; involves industry, academia, and other levels of government; establishes highly focused priorities; strengthens disciplinary research; creates multi-disciplinary frameworks; and stimulates the efficient transfer of research outcomes to operational practice.

- The Board responded to a request from Senator John McCain to examine existing policies of federal science agencies concerning the suppression and distortion of research findings of scientists employed by federal agencies and the impact these actions could have on quality and credibility of future government-sponsored scientific research results. Our central recommendation was that an overarching set of principles for the communication of scientific information by government scientists, policy-makers, and managers should be developed and issued by the Administration to serve as the umbrella under which each agency would develop its specific policies and procedures.
- The Board responded to a request from Congressman Rush Holt for a summary of its review of the evaluations and impacts of the programs of the National Science Foundation's Education and Human Resources Directorate's programs in January 2007. We will be providing a more thorough report later in 2007.
- Exercising the Board's obligation to inform and advise on critical issues, the Board sent a letter to congressional leadership on February 13, 2007, expressing its full endorsement and appreciation for the FY 2007 Congressional Joint Budget Resolution funding level increase of the FY 2006 level for the NSF Research and Related Activities account, and encouraging congressional approval of a similar budget increase for the NSF Education and Human Resources account.
- The Board published and disseminated its statutory biennial report, *Science and Engineering Indicators 2006* (NSB–06–01) *http://www.nsf.gov/statistics/seind06* and also prepared and disseminated a Board policy statement Companion Piece to Indicators 2006, *America's Pressing Challenge—Building a Stronger Foundation* [(NSB–06–02) *http://www.nsf.gov/statistics/nsb0602*], February 2006;
- Board Members provided comments to Congressman Bart Gordon on his bill, *"10,000 Teachers, 10 Million Minds Science and Math Scholarship Act"* in February 2006.

Further, the Board provided testimony to congressional hearings in 2006, and responded to other specific questions and inquiries from Members of Congress and their staffs.

Improved Outreach and Communication by the Board

The Board continues to increase and improve our direct outreach and communication with Congress, other federal agencies, various interest groups and the external science and engineering research and education community.

For example, the Board sponsored:

- Five public meetings of the Commission on 21st Century Education in Science, Mathematics and Technology (See Commission Webpage at *http://www.nsf.gov/nsb/edu_com*)
- A second and third pre-commission hearing in January and March 2006 in Boulder, Colorado and Los Angeles, California, respectively, seeking input from a cross section of stakeholders in U.S. STEM education on the value of establishing a new STEM Commission to address this topic for the Board a second time (See: *http://www.nsf.gov/nsb/edu_com/hearings.htm*)
- A third public workshop on Transformative Research (May 16, 2006 *http://nsf.gov/nsb/committees/tskfrcetrans_cmt.htm*);
- A second public workshop on engineering education reform, including leading deans of engineering, *Moving Forward to Improve Engineering Education* (*http://nsf.gov/nsb/eng_edu/start.htm*), at the Georgia Institute of Technology in November 2006;
- A public "rollout" event for the Hurricane Science and Engineering report, *Hurricane Warning: The Critical Need for a National Hurricane Research Agenda* (*www.nsf.gov/nsb/committees/hurricane/advisory.pdf*) in the U.S. Capitol Building in September 2006, with the participation by Senators Mel Martinez and Bill Nelson of Florida, and Senator David Vitter of Louisiana.

- Two public presentations on Capitol Hill on *Science and Engineering Indicators 2006* (NSB 06–02) and its companion piece, *America's Pressing Challenge—Building a Stronger Foundation* (NSB 06–02), February 23, 2006 to the media and general public and April 6, 2006 to the House R&D and STEM Caucuses;
- A presentation to Colorado State legislators at the invitation of the American Electronics Association on both *Science and Engineering Indicators 2006* and the recently completed hearings to consider establishing a new National Science Board Commission on STEM Education for the 21st Century, March 23, 2006;
- Two presentations to the National Science Teachers Association (NSTA) in April in Anaheim, California, on *Science and Engineering Indicators 2006* and its companion piece, *America's Pressing Challenge—Building a Stronger Foundation* (NSB 06–02); and
- National Science Board informational booths at the American Association for the Advancement of Science (AAAS) meeting in February in St. Louis, Missouri, the National Science Teachers Association (NSTA) meeting in Anaheim, California in April, and Sigma Xi—the Research Society meeting in Detroit, Michigan in November.

In an effort to facilitate more openness of Board meetings in accord with the Sunshine Act, we expanded our practices for:

- providing public notice of all our meetings on a dedicated NSB Meeting Notice Web site, as a supplement to the kinds of notices regularly published in the *Federal Register*;
- continuing to treat teleconferences of the Board, Board Committees, subcommittees and task forces as 'meetings,' subject to the requirements of the Government in the Sunshine Act;
- providing much more information to the public in a more timely manner regarding meeting discussions and decisions; and
- expanding efforts to encourage public comment during the development of Board publications.

FY 2008 NSB BUDGET

The Board has much to do over the next year. Perhaps one of the most important actions is to oversee the implementation of the new NSF Strategic Plan, which addresses the broad priorities established in the Board's 2020 Vision for the Foundation. We will be looking to provide policy direction to the Foundation with respect to recommendations of the newly released Hurricane Research and Transformative Research reports. Both involve broad, multi-disciplinary questions on the broad frontiers of science and engineering and across the portfolios of NSF's science, engineering and education directorates.

Our Task Force on International Science Partnerships will complete its international meetings in 2007, and we expect to be providing specific guidance to NSF and broader advice on the role of the Federal Government in supporting international S&E partnerships. Our *ad hoc* Task Group on Engineering Education is poised to present us with recommendations that will impact university engineering programs and the future engineering workforce, reflecting the input from two important workshops, incorporating the ideas of engineers, faculty, administrators, and employers in developing guidance for engineering education for the 21st Century that reflects the increasing diversity of the U.S. workforce and growing challenges for engineering from globalization of both science and technology and the engineering workforce. We will be continuing our review of program evaluations and impact in the NSF Education and Human Resources Directorate.

Over the next year, the Board expects to complete our development of a national action plan for 21st Century Education in Science, Technology, Engineering and Mathematics by making a formal report to the Congress. While many of these recommendations will be at a national system level, a number will focus specifically on the role NSF can and should play in supporting the development of an adequate and diverse science and engineering workforce. The Board will also continue to review and approve NSF's actions for creating major NSF programs and funding, and expects new efforts to be implemented regarding enhancement of NSF support for potentially transformative research as a result of new Board guidance.

Several endeavors that the Board expects to formally complete by the end of FY 2007 will require significant follow-up outreach efforts by the Board in FY 2008 to ensure the desired impacts are realized. For example, lessons learned by the Board's

experience with its 1982 STEM Education Commission report and the 2001 report on the role of the Federal Government in supporting international science, have provided clear and strong lessons on the importance of the Board undertaking significant follow-up efforts to ensure action based on our reports. While the Board's Commission on 21st Century Education in Science, Technology, Engineering and Mathematics will complete its work later this year, it is clear that much follow-up outreach by the Board will be required throughout FY 2008 to ensure the work of the Commission has the highest possible impact. Likewise, the Board's Task Force on International S&E partnerships will complete its work at the end of FY 2007, but will require significant follow-up by the Board in FY 2008.

The Board will be producing a new summary volume to our biennial S&E Indicators report in FY 2008 that will require significant new effort on the part of the Board. In addition, the Board will continue to review and approve NSF's actions for creating major new programs and funding large projects in FY 2008, as well as dealing with evolving NSF policy issues. Experience has demonstrated that the Board will receive a number of requests from Congress asking that the Board examine and report quickly on a wide range of national policy topics related to S&E research and education. The Board welcomes such Congressional and Administration requests, and will itself continue to identify high priority topics focused specifically on NSF, or more broadly on national S&E policy issues that it feels it should examine in FY 2008.

By statute the Board is authorized five professional positions and other clerical staff as necessary. The full impact of increasing the number of professional positions to the statutory level will occur in FY 2008 with increased attention to addressing new skill requirements. However, the results of a strategic restructuring of the Board Office management and operations over the last three years has led to more efficient use of appropriated resources while retaining the ability to support an active Board agenda.

ISSUES TO CONSIDER AS PART OF NSF RE-AUTHORIZATION LEGISLATION

[Our Board Office Director will be available to work closely with your Subcommittee staff to assist with development of specific legislative text to enact any of the Board's following suggestions for modification to the NSF Re-authorization Act.]

A 2020 Vision for NSF

In September 2006, the National Science Board approved a new Strategic Plan for the National Science Foundation for FY 2006–2011, *Investing In America's Future* [(NSF 06–48) *www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf0648*], articulating strategic outcome goals of discovery, learning, research infrastructure, and stewardship, and investment priorities in order to accomplish these goals. These reflect the National Science Board's *2020 Vision for NSF* [(NSB–05–142) *www.nsf.gov/publications/pub_summ.jsp?ods_key=nsb05142*], published in December 2005, establishing specific broad priorities for the National Science Foundation to:

- Drive the cutting edge of fundamental and transformative research;
- Tap the talents of all our citizens, particularly those belonging to groups that are under-represented in the science and research enterprise, and continue to attract foreign students and scientists to the U.S.;
- Develop and test new approaches to teaching science to elementary and secondary school students and catalyze partnerships among schools, museums, aquariums, and universities to put these techniques into effective practice;
- Provide the bright minds in our research institutions with the tools and instruments needed to probe the frontiers of knowledge and develop ideas that can transform our understanding of the world; and
- Maintain the financial and talent resources to be an effective agent for excellence in the critical national enterprises of learning, discovery, and innovation.

The Board would encourage Congress to factor the priorities of the Board's 2020 Vision for NSF into consideration as you prepare the NSF Re-authorization Act.

Address and examine potential impacts of a doubling of the NSF budget

In December 2003, and in direct response to congressional guidance in Section 22 of the *National Science Foundation Authorization Act of 2002* (Pub. L. 107–368, 42 U.S.C. § 1862n note), the National Science Board prepared a report, *Fulfilling the Promise* [(NSB–03–151) *www.nsf.gov/nsb/documents/2003/nsb03151/*

coverlink.pdf], to address and examine the Foundation's budgetary and programmatic growth provided for by the Act, and to outline how additional funding would be spent in the event the NSF budget were doubled. Given recent Administration and Congressional statements and actions related to future doubling of the NSF budget, Congress may wish to consider including legislative language as part of the NSF Re-Authorization Act to request the Board to prepare a report to Congress that would provide:

(1) recommendations on how the increased funding should be utilized;

(2) an examination of the projected impact that the budgetary increases will have on the Nation's scientific and technological workforce;

(3) a description of new or expanded programs that will enable institutions of higher education to expand their participation in Foundation-funded activities;

(4) an estimate of the national scientific and technological research infrastructure needed to adequately support the Foundation's increased funding and additional programs;

(5) a description of the impact the budgetary increases provided under this Act will have on the size and duration of grants awarded by the Foundation, and

(6) a description of the impact the budgetary increase provided under this Act will have on the potential to create new fields of science, to develop new technologies and to open new frontiers.

Clear statement on the critical role of NSF in pre-K–12 STEM Education

Education is a core mission of the National Science Foundation (NSF). NSF not only promotes research, but also shares in the responsibility for promoting quality science, technology, engineering and math (STEM) education as intertwining objectives at all levels of education across the United States. NSF's highly competitive peer-review process is second to none for openly and objectively identifying, reviewing, selecting, funding and providing stewardship for the very best STEM proposals and programs in research and education.

As part of our role in providing oversight and guidance to the EHR programs, the Board is assessing how well NSF supports the overall S&E education and training outcomes needed by the U.S. in a changing global environment for science and technology. This on-going review is an important action toward achieving the Board's *2020 Vision for the National Science Foundation,* submitted to Congress in December 2005, which states a near-term goal to ". . .critically evaluate current education investments and develop new strategies to increase their impact on the quality of STEM education." Reflecting our conviction of the importance of the EHR Directorate programs for the Nation, the Board has issued a number of STEM education policy reports recently, including its 2004 statement "In Support of the Math and Science Partnership Program at the National Science Foundation" (NSB–04–42) that articulates the Board's strong commitment to that NSF EHR Directorate program and its companion piece to *Science and Engineering Indicators 2006, America's Pressing Challenge—Building a Stronger Foundation* (NSB 06–02).

The Board feels strongly that NSF EHR programs not only must be effective in relatively short-term evaluations of their success in achieving desired outcomes of individual programs, but that, in combination, these programs must be effective in addressing U.S. long-term needs to retain its essential global advantage in S&E human resources. The NSF must help the U.S. sustain its world leadership in science and technology. Four examples of the many exemplary NSF education programs are: the Math and Science Partnership (MSP), the Louis Stokes Alliances for Minority Participation (LSAMP), Information Technology Experiences for Students and Teachers (ITEST) Program and the Robert Noyce Scholarship Program.

The Board will be continuing our review of NSF EHR program evaluations and results, and the use of findings to enhance EHR programs against the background of growing national needs for skills and knowledge, and the growing international competition for talent and technological leadership. We are deeply concerned that, although the U.S. must continue to attract and welcome the best international STEM talent, we can no longer depend on the global market as we have in the past for the skills and innovative talent needed in our labor force. We are convinced of the central role NSF EHR programs can and must play in preparing our citizens with the knowledge and skills needed for our nation to remain a global leader in science and technology. We are committed to ensuring that NSF EHR programs and portfolio serve our society effectively in that role.

NSF education programs provide for the collaboration between pre-college and college to promote excellence in teaching and learning, therefore facilitating the transitions for students from kindergarten through the baccalaureate in STEM disciplines. The added benefit for our nation is those students who do not choose STEM careers become the informed scientifically literate voting citizens we need for the 21st Century.

NSF has the mandate, depth of experience, and well-established relationships to build the partnerships for excellence in STEM education. The Board, therefore, strongly urges that NSF education programs be sustained and expanded over the long-term as an essential component of a coordinated federal effort to promote national excellence in STEM education. Congress may wish to address this issue as part of the legislative language in an NSF re-authorization act.

Role of the Board in approving NSF actions

Current Board policy for NSF (NSF Proposal and Award manual, NSF manual #10, December 31, 2005) requires Board approval for the following NSF actions:

(1) *Large Awards.* Proposed awards where the average annual award amount is one percent or more of the awarding Directorate or Office's prior year current plan.

(2) *New Programs.* Board approval is required for new Programs that: (1) represent a substantial investment of Program resources (threshold defined as the total annualized awards to be made by the proposed Program exceed three percent of the awarding Directorate's or Office's prior year current plan); or (2) involve sensitive political or policy issues; or (3) are to be funded as an ongoing Foundation-wide activity.

(3) *Major Construction Projects.* Board approval is required when the resulting cost is expected to exceed the percentage threshold for Board award approval.

(4) *Awards Involving Policy Issues or Unusual Sensitivity.* Board interests may include the establishment of new centers, institutes, or facilities; potential for rapid growth in funding or special budgetary initiatives; research community or political sensitivity; previous expression of Board concern; or items otherwise identified by the Director or Assistant Directors.

(5) *Requests for Proposals (RFPs).* RFPs expected to result in contracts exceeding the Board approval thresholds. Release of these RFPs to potential contractors must be approved by the Board.

(6) *Waivers.* Requests for exemption from Board review and approval of a continuing project or logistics support arrangement may be requested in routine cases where there are no significant issues or policy implications.

We feel this Board policy has worked fairly well and is at an appropriate macro-level of oversight and policy-setting without having the Board become overly engaged with NSF management and operations. However, Congress previously expressed its desire for the Board to be directly involved with approval of congressional budget requests, priority-setting, and award granting of projects in the NSF Major Research Equipment and Facilities Construction (MREFC) account. In response to Section 14 of the 2002 Authorization Act (42 U.S.C. § 1862n), the Board worked with the Foundation to produce a joint report that clearly describes the process by which priorities are set for selecting and funding large research facilities, *Setting Priorities for Large Research Facilities Supported by the National Science Foundation,* (NSB–05–77). The Board would welcome any additional guidance the Congress may wish to provide regarding this process.

Role of the Board as Oversight Body for NSF and Advisory Body to Congress and the President

From time to time questions have been raised regarding the Board role as an oversight body for the Foundation. While countless congressional budget and authorization report language, and written communications from both Republican and Democratic members of both authorizing and appropriating committees of Congress over many years have made clear the intent for the Board to serve as the oversight body of the Foundation, NSF authorization legislation does not explicitly state the Board's oversight role. Congress may wish to specifically address this issue to help avoid future debates on this topic that can, at best, be distracting for the Board, NSF Management, and the Congress. In a similar vein, Congress may also consider making more explicit in new authorization legislation the independent advisory role

of the Board directly to both the Congress and the President on national policy issues related to science and engineering research and education.

Sunshine Act Audit of the Board

Audits conducted by the Office of Inspector General over the past three years have found that the National Science Board has been in compliance with the requirements of the *Government in the Sunshine Act* (Sunshine Act). The audit requirement stems from situations prior to 2003 in which the Board did not provide public access to sessions of its committees, task forces, or other working groups. In response, Congress added language to the *NSF Authorization Act of 2002* explicitly subjecting session of the Board's subdivisions to the Sunshine Act. Congress further directed NSF's Inspector General to conduct annual audits of Board compliance with the Sunshine Act and to report audit results to specified congressional committees. Four annual audits have been completed and none has resulted in any significant finding of non-compliance. Extending the audit cycle to three years (and appropriately extending the associated document retention requirements) recognizes this fact, yet provides an efficient and regular check on the Board's continued adherence to the Sunshine Act's requirements. Congress may consider modifying the NSF reauthorization to increase the time period for audits of the National Science Board's compliance with the *Government in the Sunshine Act* (5 U.S.C. § 552b and 42 U.S.C. § 1862n-5) from every year to every three years.

Board Budget and Operations

As a result of the *National Science Foundation Authorization Act of 2002,* the National Science Board was, for the first time, given a separate budget line account in the overall Foundation appropriation. That measure served to increase the Board Office's independence and flexibility in meeting the operating and policy research needs of the Board and Board Office, such as those related to conducting workshops, issuing contracts, travel, training, etc. Increasing the availability of Board appropriated funds beyond a single fiscal year, by providing for a two-year period of availability for the Board's appropriations under "Authorization of Appropriations" (Section 5 in the 2002 Authorization Act), will provide the Board with an added degree of flexibility and, in turn, with full authority for the independent use of its resources through the Board Office. Congress may wish to consider this change in the NSF re-authorization as a further step in ensuring that the Board has flexible and independent resources to fulfill both its oversight and policy-setting role for the NSF and its role as an independent body of advisors to the Congress and the President on national policy issues related to science and engineering research and education.

At the urging of Congress, in FY 2003 the Board began examining options for augmenting its professional staffing levels. As an initial step in this process, in August 2003 the Board appointed a new Executive Officer of the Board, who also serves as the Board Office Director. At the direction of the Congress and with full concurrence of the Board, our Executive Officer reports directly to the Chairman of the Board and has been delegated responsibility for the hiring and supervision of all Board Office staff and oversight of all Board Office operations. The Board is very pleased with this arrangement. Essential to the conduct of Board business is a small and independent core of full-time senior policy, clerical, and operations staff. In addition to the Board Office's essential and independent core resources and capabilities, temporary contractual advisory and assistance services continue to be critical to support production of Board reports and supplement the Board Office staff's general research and administration services to the Board. These external services provide the Board and its Office with the flexibility to respond independently, accurately, and quickly to requests from Congress and the President, and to address issues raised by the Board itself. The Board would significantly benefit from modifications to the NSF re-authorization Act that would allow our Board Office to implement funding arrangements to periodically supplement our policy staff with technical and professional personnel on leave of absence from academic, industrial, or research institutions for a limited term. Congress may consider modifying Section 1863 (g), 1873 (a) (3) and other appropriate sections of Title 42 of the U.S. Code in this re-authorization to allow the Board to directly enter into these arrangements.

Include NSF under the Program Fraud and Civil Remedies Act (PFCRA)

Congress passed and the President signed PFCRA in 1986 to provide the executive departments, the military, federal establishments covered by the *Inspector General (IG) Act* at the time of its enactment, and the United States Postal Service with a mechanism to recover losses of less than $150,000 resulting from false claims and statements of less than $150,000, which may not otherwise be prosecuted. The Of-

fice of Inspector General (OIG) at NSF, however, (along with other "designated federal entities") was created after a 1988 amendment to the IG Act. As a result, NSF was not included in the 1986 PFCRA legislation. PFCRA has not been subsequently amended to include agencies, such as NSF, that were provided with OIGs in the 1988 amendments.

Except for NSF, every major agency that funds scientific and engineering research and education, including the National Institutes of Health, National Aeronautics and Space Administration, Department of Energy, and Environmental Protection Agency, are authorized to recover funds and assess penalties under PFCRA. NSF, too, needs to have all available means to take effective action whenever grant funds intended for scientific and engineering research and education are used fraudulently. The NSF Director, the Inspector General, and the National Science Board, all support amending PFCRA to include NSF within its jurisdiction.

Because many NSF-funded projects are relatively small in dollar amounts, PFCRA's mechanisms are well suited for resolving disputes between the Foundation and its grantees or contractors concerning fraudulent claims. Currently, the Foundation's principal legal recourse is to recommend that the Department of Justice attempt to recover misused funds through civil prosecution under the *False Claims Act* (31 U.S.C. § 3730). In general, such actions are most practical when the sums involved are very large. Under PFCRA, NSF would be able to impose monetary penalties instead of, or in addition to, debarring or suspending erring individuals and organizations. Congress may wish to consider providing the Foundation with valuable flexibility in protecting the integrity of its programs by creating a section in the Reauthorization Act amending PFCRA to include NSF. This will authorize the agency to recover funds and assess penalties under PFCRA's provisions.

CLOSING REMARKS

This is a challenging time for federal S&E research and education budgets and the organizations and individuals that rely on federal support. For over 50 years the Federal Government has sustained a continual, visionary investment in the U.S. research and education enterprise in the expectation that such investment would benefit all Americans. That federal effort has expanded the horizon of scientific discovery and engineering achievements far and wide, leading to the realization of enormous benefits to the Nation's prosperity and security.

We know the expanding frontiers of knowledge offer enormous opportunities for research and innovation. We also know that the education of all our citizens in the fundamentals of math, science and engineering must continue to be enhanced, and more American citizens must pursue science and engineering studies and careers if the U.S. is to remain eminent in critical science and technology disciplines. As other nations ramp up their investment in the infrastructure for S&E research and innovation, we cannot be complacent.

Even in a time of budget constraints, we cannot ignore the Nation's growing dependence on innovation for economic prosperity and the ever-improving quality of life Americans have come to expect. We also must be attentive to the crucial role of federal investment in science and engineering research and education, especially fundamental research that is not cost effective for private industry to pursue, and the contributions of federal support to research in universities and colleges to preparing our most advanced students for their future careers. The Board recognizes that competing priorities may impose fiscal constraints that limit the Foundation's, and so the Nation's, aspirations. In weighing these competing priorities, we ask you to keep in mind that in our changing global environment, investments in our national science and technology capabilities—talent, knowledge, and physical infrastructure—are not luxuries but essential to our nation's long-term prosperity and security. We therefore urge that the Congress take the long view in its annual budget deliberations for funding and re-authorizing U.S. science and engineering research and education through the National Science Foundation.

BIOGRAPHY FOR STEVEN C. BEERING

Chairman, National Science Board

Medicine and Higher Education

B.S., University of Pittsburgh, 1954

M.D., University of Pittsburgh, 1958

Steven C. Beering received B.S. and M.D. degrees and an honorary Doctor of Science degree from the University of Pittsburgh. Before becoming President of Purdue in 1983, he served for a decade as Dean of Medicine and Director of the Indiana

University Medical Center. He holds appointments as Professor of Medicine at Indiana University and Professor of Pharmacology at Purdue University. He retired from the Purdue presidency in 2000.

He served on active duty with the USAF Medical Corps from May 1957 to June 1969, achieving the rank of Lieutenant Colonel.

Beering has held numerous national offices, including the chairmanship of the Association of American Medical Colleges and the Association of American Universities. He is a former regent of the National Library of Medicine.

He is also a Fellow of the American College of Physicians and the Royal Society of Medicine, a member of Phi Beta Kappa, the Institute of Medicine of the National Academy of Sciences, and the Indiana Academy.

He serves on a number of national and corporate boards, including NiSource Inc., Central Indiana Corporate Partnership, Inc., Community Foundation of Northern Indiana, CID Corporation, and Marquis Who's Who. He is a Trustee of the University of Pittsburgh, and the Universities Research Association, and is Director Emeritus of the Purdue Research Foundation.

Beering was appointed to the National Science Board in 2002, reappointed in 2004, and elected Chairman in 2006.

DISCUSSION

Chairman BAIRD. Thank you, Dr. Beering.

I will take you up on the offer to get together to discuss the STEM education study you have come up with. And Dr. Ehlers and I and other Members of the Committee, who are interested, I am sure will find the time to do that, as it is of critical importance.

I also see, present in our audience, a number of the ADs for the various science directorates we met with last week. Good to see all of you folks. Thanks for being here and for your work, and also, staff from the Science Board as well. We appreciate the work of the staff.

At this point, we will open up our first round of questions. The Chair would recommend—recognize himself for five minutes.

And related to the issue of staff that I just raised, one of my first questions would be, as we talk about the idea of possibly doubling the budget, which I hope we will do over the next several years, that will carry with it some administrative needs, including workforce, infrastructure, and travel. If we just expand the number of research grants but we don't expand the infrastructure necessary to manage those grants, it seems to be that we will be in some trouble.

I open up to either of you to address that issue and any thoughts you have about how it needs to be addressed.

Dr. BEMENT. Yes, thank you.

And thank you for calling attention to an item that is absolutely critical to the quality of our work.

Many of the opportunities that the Foundation faces right now that has to do with mentoring young investigators, that has to do with post-award and pre-award oversight activities as well as maintaining quality of our merit review process is dependent entirely on our program officers and program directors.

At this present time, they are chronically overworked. I worry that they may not be picking up the transformative research opportunities for a lack of time to really dig into some of the good proposals that they are getting.

That has to be rectified, but in addition to that, we need to maintain our investments in productivity-enhancing tools, both electronic and otherwise, that takes some of the workload off our staff.

And travel is important, because you can't do post-award oversight unless you can get out and visit the investigators, either at meetings when they congregate or at their home research laboratories.

All of these taken together, plus issues of cybersecurity, modernizing our information technology within the Foundation, fall under our Agency Operations and Award Management budget line. And I would urge, in reauthorization, that that be included as a major priority, and I would also very much welcome your advocacy to be sure that we get full funding this year in our 2008 request.

Chairman BAIRD. I appreciate that. I think, you know, oftentimes when the appropriation season comes around and we look for offsets, we tend to say, "Well, we will go after the administrative line," but the administrative personnel are necessary to make the system work, and not only just the personnel, but as you say, the travel, the equipment, the resources. And it is just not responsible or realistic to say we are going to plus-up one side and not give the resources to sustain that. So we will make that a priority.

Dr. BEMENT. Thank you.

Chairman BAIRD. Secondly, I am intrigued by the process, and it is a discussion that would probably extend well beyond today, but the process by which the Board and the Foundation determine where the resources will go and what percentage of the dollars, and what total amount of dollars will go to one directorate versus another or one enterprise within a directorate versus another.

Let me throw out a thought that occurred to me the other day.

What I understand, but I think when you look at, say, the big supercolliders and giant telescopes, a tremendous amount of monies go into those, and they are expensive installations. But as I look at some of the greatest national challenges we are going to face in the next several decades, I would say if you—one would be the war on terror and the national security issue. A second would be, clearly, energy. A third would be rising health care costs, et cetera.

As I look at those, a portion of those will be addressed by the traditional physical, biological, and other sciences. But behavior, human behavior, is going to have a great deal to do. In fact, if we wanted to truly address our energy crisis in the most immediate way possible, it would not be through cellulosic ethanol, or, for God's sake, nuclear fusion, which is a little ways off, to say the least. It would be by everybody driving less and carpooling and using mass transit. And if we did that, we could cut energy consumption by 10 percent.

I raise that to ask, do we need some grand challenges in the social sciences or grand social challenges to which we would apply the social sciences, in addition to the other sciences, and how might that be considered by the Foundation or the Board in the coming years?

Dr. BEMENT. Thank you, Mr. Chairman, for that question. There is no question, but the human component in all our research is increasing because of the increasing complexity of the research. Now you mentioned interdisciplinarity. In many of our interdisciplinary programs, the social sciences are social scientists are full partners. Grand challenges are important, because the cost of doing research in the social sciences is going up because of the increasing com-

plexity and size of databases and the kind of research that they need to do in trying to analyze those type of data with advanced cyber infrastructure.

So I fully agree that we do have to give appropriate emphasis to the social sciences. We have to integrate them with all our other major programs, and the grand challenge idea is a good one.

Chairman BAIRD. Thank you.

My time has expired.

I yield to Mr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman.

First of all, Dr. Beering, you made some comments about what you would like to see in the reauthorization language. Dr. Bement, I am wondering if there is anything specific you would like to request as we reauthorize, other than saying you want all the money and no control, but——

Dr. BEMENT. Well, obviously, flexibility is important, and for lack of a prescriptive language, that would be very helpful.

I think the most important need I have already discussed, as far as our Agency Operations Award Management account. I think that deserves special notice in the reauthorization bill.

A very minor element: we do have the Waterman Award, which honors the first Director of the Foundation, and each year, we try to select one from many disciplines and many outstanding candidates. I continually get a request from the excellent committee we have that goes through the screening process, and has a very difficult time, but this may be the time to increase it to three. So I would put that before the Committee as a component of the bill.

Mr. EHLERS. Well, let me ask both of you. You have seen draft language of what is being proposed. Are there any parts that you particularly like, and more importantly, any parts you don't like?

Dr. BEMENT. The answer is yes.

Mr. EHLERS. Thank you.

Could you be a little more specific?

Dr. BEMENT. Well, I have got a large number of notes that I would like to present for the record, but clearly, under the Major Research Instrumentation section, which is Section 3, part D, we have just increased the ceiling to $4 million, and we have also increased the funding in the 2008 request to $114 million. We don't know yet what the skew will be of that distribution and who we may be disadvantaging in the lower cost instrumentation across our constituency and especially in some of the minority-serving institutions and other institutions. My recommendation there is to increase the ceiling step-wise as we increase the budget, rather than to raise the ceiling so high that one or two awards would greatly disadvantage a larger number of applicants for important equipment.

I think Section 5 is a good section. As far as interdisciplinary research, we have already addressed that, and there is always more that we can do, but invariably, it deals with the nature of the science question that needs to be addressed and how the community responds to that.

So as a bottom-up organization, we really can't define all of the opportunities for interdisciplinarity, but we certainly encourage it. We have been at this now for 25 years, and finally, the universities

are getting religion and have begun to produce the silos a little bit. So in our unsolicited proposals, we are seeing an increasing fraction, and now it is up to anywhere from 40 to, perhaps, 50 percent. There are multiple PIs, and many of those are interdisciplinary, but they are unsolicited.

And I could go on. There is much more in here.

Mr. EHLERS. Well, we would certainly appreciate having that for the record.

Dr. Beering, any comments you wish to make?

Dr. BEERING. Yes. We addressed that issue and others in my written testimony, starting on page 14, and we also addressed it in a previous hearing on March the 20th.

And let me comment specifically on your Section 6 on new investigators.

We are struggling with how we can get transformative research front and center in our endeavors, and I think this new section here is going to be helpful in that regard.

And then Section 11 on STEM education is very vital. I expect that our STEM education report is going to recommend some specific action plans, one of which is to increase the length of the school year. As you compare ourselves with Asia and Europe, it is astounding how much more time their students spent in class and formal instruction than ours do and some of the requirements they have for science and language, which we do not have.

So I would highlight those two items as extremely helpful.

Mr. EHLERS. Dr. Bement.

Dr. BEMENT. Let me bring up one other section that I think is critically important, and that is Section 12 on cost sharing.

Let me first emphasize that we accept cost sharing. In fact, we encourage it, we just don't require it. And the reason we don't require it is that there are many institutions and many investigators that can't get a cost-sharer, especially, again, among minority-serving institutions, for example. To put it in as a requirement disadvantages them from even being able to submit a proposal, and I think that is wrong. I think we should continue to encourage cost sharing, but we should not mandate it.

Mr. EHLERS. Thank you, both.

I see my time has expired.

Chairman BAIRD. Thank you.

Dr. Bartlett.

Mr. BARTLETT. Thank you very much. I appreciate, very much, you being here.

I have two issues I would like to pursue.

One is the huge problem that we face in this country in two dialogues, major dialogues that we are having in agreement of the facts. It is very difficult to have an intelligent conversation if you can't agree on the facts. Of course, we are all privileged to have our own interpretations, but we shouldn't have our own facts.

The two areas that I am thinking of, one of them is climate change and global warming. And to whom should we turn? Your organizations are certainly among those. To whom should we turn as an honest broker so that we can have some agreed-upon facts for this discussion?

Dr. BEMENT. Well, Dr. Bartlett, it is good that you brought up that question, because I just came from Dartmouth University where we had all the arctic nations come together and discuss that for about three days.

The evidence is clear. There is climate change. There is global warming. There are anthropobenic effects. We need to understand the extent of those types of effects. The trends are not looking good. In fact, they may not be linear. In fact, I suspect they are not linear. They can become autocatalytic over time, so you just can't take what has happened in the past and project it very comfortably into the future.

I think it is a global problem that will require global approaches to research and global approaches to mitigation.

Mr. BARTLETT. To whom do we turn for some agreement on what the facts are so that we can have an intelligent conversation? Another area that is very important is the energy area and peak oil. And if, in fact, we have reached, as many people believe we have, the maximum capability of the Earth for producing oil from conventional sources, then we, in the United States particularly, in the world in general, faces a very uncertain future.

Dr. BEMENT. Well, I would recommend you turn to the National Science Foundation. First of all, we don't fetter any of our staff or any of our grantees in taking an open stance on any issue. In fact, we have requirements in our grant manual that requires open sharing and open publication and open discussion of issues. So that goes on all the time. And certainly, we would welcome any questions you have on any of those issues. And certainly, working with the National Science Board, that is an ideal place to raise some of those issues.

Mr. BARTLETT. As an example of one of the areas, and you mentioned the cellulosic ethanol, there is now a lot of hype about cellulosic ethanol. A speech was given by Hyman Rickover, 50 years ago the 15th day of this May, to a group of physicians in St. Paul, Minnesota. And in that, he noted that the time would come when we needed—when we would have to change from fossil fuels to renewables and that there would then be a tension between food and energy, and we have seen that tension in corn ethanol. We produce relatively trifling amounts of ethanol from corn, but we doubled the price of corn, and tortillas have gone up so that poor Mexicans can hardly afford to buy them. And our dairy industry is dying now because of the increased price of corn.

So now, we are turning to cellulosic ethanol, but Hyman Rickover also noted that there was going to be a tension between energy and soil fertility. What is the potential for cellulosic ethanol? To whom should we turn for a rational analysis to this, because now there is a lot of what I think is irrational exuberance over this?

Dr. BEMENT. First of all, I worked with Admiral Rickover in the Pentagon, and I—some years back, and I had an opportunity to see how his mind works, so it doesn't surprise me a bit that he was 20 years or 30 years ahead of his time.

Cellulosic ethanol is an opportunity for the future. There is a lot of research going on at the present time to determine how to break cellulose, as well as lignin, for that matter, and to do it economi-

cally through better enzymes and through better bacteria strains to convert cellulose to starch to alcohol.

I think the hidden challenge is water. This nation is going to be challenged for water supply, and you can't produce ethanol without water. And so the idea that you can go into the grasslands and suddenly set up huge factories to produce cellulosic ethanol or even corn-derived, fermented alcohol, I think, is a little bit too optimistic unless you can figure out how to pipe water to the production facilities. My feeling is that Michigan is probably in a very good position, as compared with, say, South Dakota.

Mr. BARTLETT. Thank you, Mr. Chairman.

Chairman BAIRD. Dr. McNerney.

Mr. MCNERNEY. Thank you, Mr. Chairman.

Thank you, Mr. Ehlers.

I want to commend the Board. I spent my career—I am a new Member of Congress, and I spent my career in the research and development area, and I have always been impressed with the National Science Foundation, the sorts of projects that are funded, how efficiently they work, and so on. So I think it is a very good operation. I am proud to be on the Committee overseeing that operation.

Now I have a couple of questions.

My first question is a structural issue.

What, specifically, is being done to award—in the merit review process, to award new researchers as opposed to researchers with a track record of publications? And in that process, how can we make sure that we are being fair to the more seasoned researchers?

Dr. BEMENT. Well, as I mentioned in my opening remarks, we take a look at what I would call market share, which is a surrogate for competition, competitiveness. And when we see that new researchers are garnering about 28 percent of the awards, that is good, in itself, but it has been stable over a time when the success rate has gone down, which means that we are now in a more competitive time than we were maybe six or seven years ago. But at the same time, we have been able to sustain that market share for younger investigators.

The one thing that I have tried to do is to put more emphasis on unsolicited grants, because it is usually unsolicited grants where young investigators get their start. They build their research teams, and they have a bright idea, perhaps an extension of their dissertation, but perhaps not. And I can report that when I came into the Foundation, the percentage of research grants that were unsolicited was at 71 percent, which means that 29 percent were solicited. Today, the unsolicited grants are up to 80 percent, and the solicited grants are at 20 percent, which indicates we are skewing the opportunity for these types of, you know, grant proposals from young investigators.

The other thing is that every young investigator has to go through a learning curve. When they first come to a university, they have got to set up a research group. They have got to equip a laboratory, and then they have to figure out what the first graduate student is going to work on. And then usually the first two or three proposals don't make it. So they need feedback, and they need encouragement, and they need mentoring in getting up that

learning curve. And our program officers are absolutely masters at providing that type of guidance and that type of feedback. But again, I go back to my earlier point. They are very much overworked, and the more opportunity we give them, the better they can do their job.

Mr. MCNERNEY. Okay. I have an unrelated question.

I did—I am struggling through the report *"Rising Above the Gathering Storm."* In the—it is a disturbing report, and I agree with the conclusions.

Now our subcommittee was informed that only two of the eight division directors and deputy division directors in the NSF education directorate are filled by temporary employees, and the other six positions are vacant. Now I am glad to see Dr. Marrett in the audience, but has that situation changed or is there something that we need to take steps on in that regard?

Dr. BEMENT. Well, the reason the situation has changed is because Dr. Marrett is on board, and she is looking to fill in those positions and to develop her own team. But let me ask if she wants to add anything. Those positions will be filled very shortly.

Mr. MCNERNEY. Okay. All right. Thank you.

I yield back.

Chairman BAIRD. We have been joined by the Ranking Member of the Full Committee, Mr. Hall from Texas.

Mr. HALL. I yield my time at this time. I thank you.

Chairman BAIRD. Thank you, Mr. Hall.

Dr. Lipinski.

Mr. LIPINSKI. Thank you, Mr. Chairman.

Earlier, Ranking Member Ehlers had mentioned his great esteem that he holds for NSF, and I certainly will concur with that. And it is good to see, Dr. Bement and Dr. Beering, both of you here today. And I will always hold NSF especially in high esteem, as I always say to you, because I have applied for one NSF grant in my life, and I received it, so I am always very happy with NSF. And that was as a—that was a dissertation improvement grant, and so I am especially attuned to the importance of nurturing young investigators.

But what I want to ask about here, going down to a lower level in terms of school level, I am pleased to see that the President's American Competitiveness Initiative proposes doubling the research budgets, but the education budget is getting a much smaller increase, and we continue to see the latest NAEP results, problems that high school students are having, 40 percent scoring below basic math level. But we are not seeing the increases or we are seeing decreases in the funding for education at NSF.

Now how is NSF going to accomplish the goal of reversing these trends and educating more, bringing up the education level of science, math, STEM education in general with these underfundings in these crucial areas?

Dr. BEMENT. Well, let me say, Congressman, that education is fairly one of our highest priorities, if not the highest, and we work closely with the Board on this issue. You ask about national needs and whether the Science Foundation is addressing national needs. I can't think of a more important national need at the present time

than education. And here I am talking about K to post-doctorate; continuity all up the learning ladder.

Our focus is pretty much in three areas. Clearly, one is to produce more STEM-educated teachers and also to upgrade the content proficiency of existing teachers, so teacher preparation and in-service training are critically important.

The second major priority is to fill up the pipeline to encourage students through better instruction, through more excitement in the classroom, through more activity-based learning, through better integration of informal education with formal education so that science museums, members of the media, and even communities can be engaged.

Mr. LIPINSKI. I appreciate all that, but are you concerned that in the proposed budget there is not enough funding for education and that, perhaps, NSF is, in some ways, being squeezed out of the K–12 education sector?

Dr. BEMENT. Well, I think that is turning around. We do have the opportunity in 2008 in our Math and Science Partnership to award $30 million worth of new grants, and I think that came about as the result of the evaluation of that program to show that it was very effective in increasing both math and science proficiency. So we hope that sent a different slope at the present time, a positive slope instead of a negative slope.

You know, any other programs that we have targeted because of their effectiveness. Some deal with undergraduate education, but the GK–12 program, which is a program that makes possible graduate students going into the classroom in K–12 classes to serve as a resource base in teaching math and science, working with the teachers, working with the students, and that has turned out to be one of our most effective programs by providing that role model in the classroom.

Some of these programs were not plussed-up in 2008, because they are still undergoing evaluation, and at the time the budget was being put together, we had the mandate from Congress that we establish the American Competitiveness Council. And the sense of Congress was that programs shouldn't be substantially increased unless they had been shown to be effective through third-party or rigid evaluation.

Some of the programs that were flat-funded are undergoing evaluation in 2008. Some will be completed in 2007, so my full expectation is that we will continue to push on these programs and try and plus them up in the future budget cycles.

But your point is well taken. We just have to continue pushing on the NSF role in education.

Mr. LIPINSKI. If the Chairman will indulge me for another 30 seconds, I just want to say I am looking forward to the National Science Board's STEM education proposal that will be coming out.

And I am also interested, and maybe I will follow up later, about what is going on in terms of NSF with nanotechnology and the National Nanotechnology Initiative, what NSF is doing and also about the Interagency Hydrogen and Fuel Cells technical Task Force, what is going on with that. But I will yield back right now.

Chairman BAIRD. Thank you, Dr. Lipinski.

Mr. Hall is prepared to ask some questions at this point.

Mr. HALL. Yes. Thank you. And I am sorry to be late. Most of us—all of us, I guess, have other committees that require a lot of our time, and I didn't know what questions had been asked, Mr. Chairman, but you are very capable of handling this, and I appreciate you and appreciate the things in your background.

And Dr. Ehlers, of course, is one we go to, and he is really the champion of the National Science Board and folks that are taking the leadership there.

I wanted to ask Dr. Beering and Dr. Bement, I guess either one of you, most of the K–12 education fund in the President's American Competitiveness Initiative is for programs at the Department of Education, and our Committee has a few bills before it that speak to K–12 education at the NSF, particularly H.R. 524, which was a partnership for access to the laboratories science bill, and H.R. 362, the *10,000 Teachers, 10 Million Minds Math and Science Scholarship Act.* Now I guess I would ask you to comment on those bills, if you would, in post-hearing questions.

But for now—I will ask that later. But what other role should NSF have with regard to the competitiveness agenda and the K–12 STEM education? Dr. Beering, do you want to go first?

Dr. BEERING. I will defer to——

Mr. HALL. Or do you want to go second?

Dr. BEERING. I will defer to my colleague, yes.

Mr. HALL. All right.

Dr. BEMENT. Thank you, Mr. Hall, for that question. It is a very important question.

The funding provided to the National Science Foundation for education amounts to one-tenth of one percent of the total funding that goes into education, the K–12 education. So it is a very precious resource. And that resource needs to continue to be focused on research and development, because there is very little funding that is available for research and development in education to develop better methods, better instruction materials, better teacher training, and so forth.

And that means that at the end of our process, as we get into advanced development, we will be able to show that these programs are effective, have an impact, can be scaled, can be transferred, and are sustainable. Those are the principle objectives of many of our programs. It requires effective partnerships with the states, with the school boards, and with other entities in order to hand that off and carry it into implementation. That is what we spend a lot of time in our programs doing, is establishing partnerships, the Math and Science Partnership program is a clear example, in order to carry those new methods and best practices into implementation. And that will continue to be our approach.

The one thing that would really drain our resources is if we—in any bill, we are asked to really take on the implementation role, because that is more than we could possibly handle with any foreseeable resource that we could be assigned.

So I would urge the Committee to pay attention to some focus on education, research and development, and appropriate resources for the research and development in these bills.

Mr. HALL. Do you care to add to that?

Dr. BEERING. When we come forward with our STEM Commission recommendations, I wouldn't be surprised if you will hear that one of the most important changes that is necessary for America is revision of our attitude and commitment at the family and community level. As I have traveled around the country and the world in this regard, I am struck by the fact that we send our kids off to school and forget them there, and the families and the communities are perfectly happy with that arrangement. We are going to have to re-evaluate that. That won't cost any money, but it will certainly wrench the way we look at things.

Mr. HALL. Those are two good answers. I like those: it doesn't cost any money and it does more.

I have one other question I want to ask Dr. Bement.

I don't think the Committee plans to hold a separate hearing for the NSF fiscal year 2008 budget, so if you would oblige me, just for a moment, to ask a few questions related to that.

The fiscal year 2007 joint budget resolution is favorable to NSF's research and related activities. This may have been asked. If it has—however, most of your other programs remain at the fiscal year 2006 levels. What impact will this have on the agency? And have you asked that, Dr. Ehlers?

Dr. BEMENT. Well, it is a very good question.

Obviously, we are very grateful and very excited about the increase in the Research and Related account budget. That will allow us to go forward with a number of new initiatives.

The two areas that are still problematic for us is the EHR budget, which you have indicated. If we look at the increase from 2006 to 2008, there is a fairly healthy increase in much of the EHR budget, but it would have been very gratifying if we could have gotten some attention in the continuing resolution for EHR.

The other part that is strained, at the moment, is that we have all of this wonderful money in our research account, but we didn't get any money in our Agency Operations and Award Management account. So we are already starting from a situation where we have an extreme overload on our program officers. We've only exacerbated that. That is both the good and the bad part of it.

Mr. HALL. I thank you. And I think Dr. Ehlers has already inquired about the industry partnerships, the parts of the language you like and don't like and the drafting recommendations.

I yield back my time, and I thank you.

Chairman BAIRD. Thank you, Mr. Hall.

We will have another round, if the witnesses are available for a few more minutes.

Great, then as per the custom, we will continue to go back and forth between both sides.

Just a very quick thing, I don't want to take too much time with it, but Dr. Bement commented earlier about NSF's policy to allow but not require cost sharing.

Dr. Beering, is the Board consistent with that perspective, that the allowance of cost sharing is supported by the Board?

Dr. BEERING. Yes, indeed.

Chairman BAIRD. Okay. That is good to hear, because I think it is important, I fully believe. Industry, which is coming to us through *"Rising Above the Gathering Storm"* and a host of other

studies is pointing out that we need a well-educated workforce and scientists. And I think it is important that they play a participatory role in that process. And I want to make it possible—make sure we make it possible for them to do so. And indeed, while I wouldn't require it, I would encourage. I think Dr. Bement's point is well taken that not everyone can obtain such a cooperation or co-funding, but to the extent that someone can help bring that to the table, I think there is a nice synergy possible, and it should be allowed.

A question I have—that occurs to me, as I have talked to some of the discipline-based scientists in some of the universities, is—can we use the NSF grant process for research to facilitate the educational enterprise and the educational enterprise of two levels, one educating more scientists per se, but also educating more science educators. And it seems to me there is potential for either competitiveness or complementariness between grants. And let me give the example: If we award a large research grant to an individual, does that possibly insulate them? Depending on how we structure the grant, does it possibly insulate them from the activity of actually training new scientists or training science educators? Or are there ways we can structure grants to incentivize those who educate to directly involve themselves in the education of scientists? I talked to one scientist who said, "You want us to start making sure we educate enough scientists? Tie our grants to it." He knew where his bread was buttered.

And I would be—I welcome your thoughts about that.

Dr. BEMENT. Well, I am absolutely floored that that question came up, because in our Criterion 2 for our grants, "other impacts," that, clearly, is an area of focus. And we not only encourage it, but we expect it. Not only that, but we also require accountability. So it is not just reporting on the good science that was done under scientific merit. It is also important that they report on how they fulfilled their promise in Criterion 2, as far as education is concerned.

The other thing that I would mention is that a good bit of our education and research on education is really carried out by our research directors. It is not done just in EHR. In fact, there is a very close partnership, mutually leveraging education, that can be supported by the research directors in bringing new content knowledge into not only undergraduate education, but also K–12 education.

So we need to do a better job in our website to make sure the community really does understand that.

Chairman BAIRD. Well, if two identical grants were to arrive at the desk of the reviewers, with the sole difference between them that one places explicit and greater emphasis on utilizing a portion of the grant to educate new scientists and to coordinate with the *Science Education Act,* that would be looked on more favorably, conceivably, if every—all other——

Dr. BEMENT. Well, there is the question of whether we would give preference in Criterion 2 for education or for industry-coupling and so forth.

The one thing that we have to be very cautious about is that we don't use "other impacts" as a trump against scientific merit, because the scientific merit has to be there, and it has to be solid, otherwise, we begin to tarnish our gold standard of merit review.

But those things are all taken into account by our panels and the chances are pretty high that they will be considered.

Chairman BAIRD. We have yet to address issues of—in any detail today, of encouraging and supporting researchers of diverse backgrounds, and particularly ethnic diversity or economic opportunities and also gender issues.

I would appreciate either of you commenting briefly on that in what remaining time I have left.

Dr. BEMENT. Well, broadening participation has been a high priority in the Foundation since I have come. It is in our priority list. It is in our strategic plan. It is up front in all of our research directorates and research offices. They take that very seriously. In fact, if you look at the total investment across the Foundation, with broadening participation, about a quarter to a third of that is funded through the research directorates and research offices in a variety of ways. And of course, that only provides internal leverage to be able to do more than we are currently doing.

So I am pretty proud about the wide variety of programs that we have that are dedicated to broadening participation and the way that we can integrate those to get more impact and more leverage.

Chairman BAIRD. Dr. Beering, do you care to comment on that?

Dr. BEERING. I would certainly agree with that. I am reminded of an experience I had while I was Dean of the medical school at Indiana. The accrediting commission came by and said, "Why don't you appoint a woman plastic surgeon?" And I looked around, at the time, and there weren't any. And we have certainly fixed that issue, and it was by way of first finding out there was a problem and then paying attention to it in the way that Dr. Bement has described.

Chairman BAIRD. Thank you, Dr. Beering.

Dr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman.

First of all, just a comment.

Several years ago, several of us in the Republican majority were successful in getting a bill through the Congress to double the NSF funding in five years, and that eventually led to the present doubling plan, doubling in 10 years.

Many of the problems we discussed here would be solved by having some additional funding. So in my mind, five years is better than 10 years. So let me challenge the new majority to try to go back to the bill we passed. And I encourage you to do whatever you can to meet that standard.

The other comment, we talked a bit about the young scientists versus the older scientists. Let us take just a broader view of that. Years ago, I know that Europe was very concerned about the brain drain of scientists moving to the United States. I am starting to discern a brain drain the other way because of a lack of adequate funding here and increasing funding in other countries. We have actually lost ground compared to other countries, several other countries, for rapidly increasing their research funding.

I personally know a scientist who moved to Europe recently. He was tired of struggling with annual grant requests and thought it would be wonderful to have a lifetime appointment with a guarantee of research funding.

That is our competition. And so I just wanted to mention there is that aspect of it.

Another one, we make a great deal about peer review in the United States, and I think it is excellent, but it is also very important to have peers. And I talked to a young scientist recently who is not at all happy, because—and it was not just young scientists versus older scientists, but this person had a very good new approach, was being recognized in the field for that, applied for an NSF grant, and was appalled at some of the comments by some of the so-called peers who reviewed it in which the comments indicated a basic misunderstanding of the science involved, obviously, who were not familiar with it. He was even more discouraged when he contacted the person in charge of that directorate and talked to him and found out he also did not understand.

So I think a major chore is not just worrying about young scientists getting it, but recognizing that many times the young scientists have new ideas that, if someone has not been active in the research field for a few years, may have passed them by.

So it is a multi-faceted problem. It is not just young versus old.

Dr. BEMENT. Yes.

Mr. EHLERS. And I think you could make a good argument for dramatically increasing the funding for young scientists, but also we have to have a good peer review.

Dr. BEMENT. Even though there wasn't a question there, I do have some opinions on those remarks.

First of all, in our peer-review process, inasmuch as we are emphasizing frontier research, we do try to include younger scientists who are pretty well recognized, because they know where the frontier is and they know what is important at the frontier and where the important research is being done. And that has been a very positive contribution in our panels and even our individual reviews.

But we do have due process within the Foundation where investigators who have been declined, can challenge the decline. And that goes through several steps of review all of the way up to the Deputy Director. So there are ways in which someone who feels that they haven't had an adequate peer review can get the attention of the Foundation.

Mr. EHLERS. I hope you also recognize that the reluctance of a new researcher about doing that and alienating the leadership of the NSF.

Dr. BEMENT. I do, indeed.

Chairman BAIRD. How often is that actually done, Doctor, that someone appeals a—especially successfully appeals a——

Dr. BEMENT. Well, it is not very frequent. As the Deputy Director indicated, she has only had one appeal that came up to her level as a final appeal step, and it wasn't worthy of consideration, so it was denied.

Chairman BAIRD. Dr. McNerney.

Mr. MCNERNEY. Thank you.

As we have sort of been talking this morning, education is one of the issues that challenges our country in terms of science and technology. And I think it is—a lot of it is a cultural issue. Many of the young people don't look at science as a profession nor engineering as a profession that appeals to them. Is there anything

that can be done within the National Science Foundation to sort of change that perception or attack the cultural issue that we are facing in terms of attracting young people into this profession?

Dr. BEMENT. Absolutely, there is, Congressman.

The focus right now is introducing science earlier in elementary school, perhaps third to fifth grade, and even engineering, for that matter, because that is hands-on, and that can excite children toward science and engineering and give them some early understanding about what these fields are all about.

The other thing that we can effectively do is try and work at the interfaces between primary and secondary education, secondary education and community colleges, and with institutions of higher learning, universities and colleges. And this is the continuity I was talking about, because, oftentimes, a child will have a wonderful experience in elementary school and transition to a secondary school that may be a troubled school that may not have very adequate teaching talent in STEM education, and then it suddenly dissipates, it is a turn-off. And the same thing between high school and college. So there needs to be more effective attention given to reducing the barriers and coupling preparation with expectation and entrance requirements at universities so we don't lose people from those pathways as they move through the system. And that is where a lot of our effort is focused.

Mr. MCNERNEY. Well, in my district, there are some economically-disadvantaged areas, and I see a lot of young people that aren't engaged in the process. And what I would suggest is that we find a way to make the science more glamorous looking or engineering more appealing, because that is what it is going to take. We are going to have to go across those barriers to get people involved, to make children understand not only the practicality but also the beauty of science. And so that is my recommendation.

Dr. BEMENT. No, you are absolutely right. This is where the business community can come in, because we know that even in some troubled areas where the business community is not only committed but actually engaged, and where they can provide release time for their scientists and engineers to work with the public schools, that makes a difference.

Also, again, coupling informal with formal education can be a way of exciting young minds to what science is all about, and that is a very effective program. In fact, as I go to public schools, I ask the young children, do they know about the National Science Foundation. Only a few hands go up. But when I mention some of the television programs that we sponsor, almost all of the hands go up, which makes me feel very good.

Mr. MCNERNEY. Thank you. I yield back.

Chairman BAIRD. Dr. Bartlett.

Mr. BARTLETT. Thank you very much.

The Chairman noted the relatively large contributions to energy that conservation could make, like buying a more efficient car or carpooling as compared to hard-run contributions of additional energy from alterative sources, which reminded me of a very interesting graph that on the ordinate has satisfaction with life, how good you feel about your life. And on the abscissa is per capita energy use. And if you can imagine that little graph in your mind's

eye, we are way up at the upper right. This one person in 22 using a fourth of all the energy in the world, and there are 150-some countries, and they polled each of these countries how good they felt about their life, and they put a little spot on the graph. And not too surprisingly, way down on the left side of the graph, you have to have some meaningful amount of energy before you could feel good about your life. But that curve rises very steeply there. And after rising very steeply there, it then approaches something of an asymptote that gets a little bit beyond where we are. But there are 27 countries in the world who use less energy than we, some of them less than half as much energy as we use, who feel better about their station in life than we feel.

And I mention this because as big as the challenges are in the hard science areas, I think the biggest challenges for the future are going to be in the soft science areas. We are just going to have to get used to, as a world, and particularly in this country, living with less energy. And that is going to be a real challenge in the soft science areas. Now I come from the hard sciences in my personal training, but I recognize that in the future, we are going to have really big challenges in the soft sciences. Is this a role that the National Science Foundation plays or do we need to look for another entity for leadership here?

Dr. BEMENT. No, Dr. Bartlett. It is a role that we are playing, and we pay a lot of attention to it.

I might indicate that we do have energy initiatives in hydrogen and fuel cell technology and advanced combustion, other means of conservation, including renewable fuels. And of course, these are proposals that are sent to us by top-ranked scientists who are really looking at the frontier of these fields and looking way, way ahead into the future.

But your point of bringing in the human factors associated with energy production and energy use and also satisfaction are very important components. I think one of the reasons why we are probably energy hogs, but not as well satisfied as we would like to be, is because of differences in productivity but also the fact that we work ourselves to death compared with other nations where their lifestyles are considerably different.

That is a very rich area for social science and for understanding human factors.

Mr. BARTLETT. I am glad you mentioned hydrogen and fuel cells in the same breath, because, as you know, and I suspect not everybody knows, hydrogen is not an energy source. It is simply a convenient way to carry energy from one place to another. And of course, when you burn it, you get only water, which is not very polluting, but if we are really going to exploit the potential of hydrogen, it has to be with a fuel cell, doesn't it, because——

Dr. BEMENT. Yes.

Mr. BARTLETT. This is a great candidate for a fuel cell, and in a fuel cell, you get at least twice the efficiencies you get in a reciprocating engine. Just burning hydrogen in a reciprocating engine doesn't make much sense.

Dr. BEMENT. Well, you put your finger on it, and you are absolutely right. You have to look at net energy used, which means that you have to take into account the energy used in the production of

hydrogen. And if you are going to use energy, a fair amount of energy, especially thermal energy or electrical energy in electrolysis, for producing hydrogen, you had better darn well get it back with a higher-efficiency engine.

Mr. BARTLETT. Thank you very much.

Thank you, Mr. Chairman.

Chairman BAIRD. Dr. Bartlett, as always, insightful questions, and I appreciate that, as often comes from Members of this committee.

One final question, and then we will adjourn.

I am very interested in the role of technical education and particularly sciences in the role of technical education.

As I have talked to a number of our major employers back home, yes, they need top-flight scientists to do the high-technology engineering and research, but they also need folks who can just work in a high-technology environment, do such things as basic math, averages, scatter plots, the kind of things that, unfortunately, oftentimes, our high school graduates can't do.

Could you, either of you, talk briefly about the technical education aspects of NSF and what you see as the future of that?

Dr. BEMENT. I am going to address it in a way that Dr. Beering can also address it, because, coming from Purdue, I am familiar with the outstanding technology program that they have.

Oftentimes, when we compare ourselves with China and India, we talk about the large number of engineers they produce and compare it with the number of engineers we produce. But oftentimes, we don't include technicians and technician training in the equation. And yet, if you look at what those people do, our technicians are fulfilling jobs in the workplace very much like the engineers in other countries are fulfilling. So we ought to pay attention to that.

Through our Advanced Technological Education program, our ATE program, we have developed partnerships with industry. In about 90 percent of our ATE programs, community colleges work in cooperation with the private sector. And the reason why those partnerships are critically important is that the private sector has the jobs. They know what skill requirements they are going to need, not only today, but in the future. So those industry leaders are the ideal people, and their engineering staffs, to help structure the curricula for these community colleges. In all of their evaluations, we are finding that that is one of the most effective programs we have in the NSF, not only in training top technical talent, but taking away the excuse, in the private sector, that "we have to go abroad because we can't find the technical talent we need here in the United States." I would like to see us get rid of that through more investment in our ATE program.

Chairman BAIRD. Dr. Beering, any comments?

Dr. BEERING. Yes, we are going to speak to that with our engineering and also STEM task forces very shortly. And I would second what Dr. Bement has said. The concern about the Chinese engineers, for example, is that we haven't identified who these people really are, and they are mostly technologists rather than engineers in the sense that we employ that term. So the differences are not as dramatic as they appear on the surface.

Another problem we have, anticipating what you will hear from our STEM group, is that we do not welcome working professionals into the educational system. There are licensure problems and cultural blocks, and we need to do that. There are lots of retirees, for example, that would be delighted to come into the educational curriculum work, and I hope that we can get that done.

Chairman BAIRD. I note, for example—I appreciate that, Dr. Beering. Neither Dr. Ehlers nor I would be certified to be able to teach in our respective disciplines at the high school level——

Dr. BEERING. Right.

Chairman BAIRD.—and interestingly enough, on the vocational front, I know that some top-flight welders, folks who have worked their whole life in welding and know it inside and out, couldn't teach—couldn't get a teaching certificate. I think we ought to look at that.

I thank our witnesses. Are there other comments or questions from the panel?

If not, then, before we bring the hearing to close, I want to thank our witnesses for their outstanding work and for testifying before our subcommittee. This has, indeed, been a highly educational experience for us. And our witnesses have given us a lot to consider as we proceed with developing and marking up legislation to authorize programs at the National Science Foundation.

If there is no objection, the record will remain open for additional statements from the Members and for answers to any follow-up questions the Committee may ask of the witnesses.

Without objection, so ordered.

The hearing is now adjourned. Thank you, again.

[Whereupon, at 12:00 p.m., the Subcommittee was adjourned.]

Appendix:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Arden L. Bement, Director, National Science Foundation

Questions submitted by Chairman Brian Baird

Industry Internships and Partnerships

Q1. In the IGERT program, students may do industrial internships. What percentage do intern in the private sector? What other programs besides GOALI promote or allow industry internships?

A1. Approximately 22 percent of students who have participated in the Integrative Graduate Education and Research Traineeship (IGERT) program have reported that they have done research with industrial scientists in the United States. NSF has a large number of programs that promote and encourage industry/academic partnerships which provide student exposure to industry, without formal internship components. Examples of such programs are the Partnerships for Innovation (PFI), the Industry/University Cooperative Research Centers (I/UCRC), and the Information Technology Experiences for Students and Teachers (ITEST). NSF supports a number of programs that sponsor formal graduate and undergraduate internships with a focus on industry. For example, the Engineering Research Centers (ERC) supported by the Directorate for Engineering (ENG) requires that each ERC form a partnership with industry. Industrial personnel work closely with the faculty and students providing guidance on industrial interests in research, sponsoring fellowships and internships for students to carry out research on site in industry. The Mathematical and Physical Sciences Directorate (MPS) also has several notable programs that connect students with the private sector. For instance, the Research in Industrial Projects (RIPS) Program allows high-achieving undergraduate students to work in teams on real-world research projects proposed by a sponsor from industry or a national lab. The Statistical and Applied Mathematical Sciences Institute (SAMSI), the Institute for Mathematics and Its Applications (IMA), and the Mathematical Biosciences Institute have programs that foster industry/academia partnerships which offer student internship opportunities, quite relevant to the American Competitiveness Initiative (ACI). The Education and Human Resources Directorate (EHR) also supports programs that promote industry/academic exchange. An example includes the Advanced Technological Education (ATE) program which focuses on the education of technicians for high-technology fields through activities such as student internships in industry.

Q2. Does NSF have any officials designated as "liaisons" to industry to facilitate NSF/industry partnerships outside of formalized program structures. Does such contact occur through divisions sponsoring formal industry-partnership programs such as the Centers? Or is all of the contact made by the grantees themselves?

A2. Forging partnerships with industry is important to NSF. It helps expedite the transition between basic and applied research; strengthens the economy; and encourages innovation and productivity. While discussions and interactions with industry occur at events such as conferences, symposia, and workshops, the majority of NSF-sponsored partnerships develop through formal programs that encourage collaboration among academia, industry, and government. Several NSF programs are focused on partnering with industry. These programs include the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR), the Partnerships for Innovation (PFI), the Grant Opportunities for Academic Liaison with Industry (GOALI), and the Industry/University Cooperative Research Centers (I/UCRC) programs. The Engineering Research Centers (ERC) program requires each ERC to form a partnership with industry through a membership agreement. In addition, the ERC Program requires that each ERC have a staff person designated as an Industrial Liaison Officer to facilitate the interaction between industry and the faculty and students and work with industry to speed technology transfer. To enable innovative research and education projects of national importance that require a center-mode of support, the Science and Technology Centers: Integrative Partnership (STC) Program encourages partnerships among academic institutions, national laboratories, industrial organizations, and/or other public/private entities. STC partnerships build intellectual and physical infrastructures that weave together the creation, integration, and transfer of new knowledge. To support this effort, the STC Program requires that each Center establish an External Advisory Board which must include industry representatives and designate a staff person who is respon-

sible for knowledge transfer activities. Moreover, the STC Program includes representatives from industry as members of review and site visit teams. In addition, several other NSF programs, such as the Math and Science Partnership, have an industry-related component designed to promote public/private partnerships.

In addition to NSF's formal programs, NSF is making a strategic effort to improve communications and develop relationships with a broad spectrum of companies from multi-national firms to start-ups. The goal is to exchange facts and information in order to meet the challenges of the future and to form cross-sector partnerships. We have organized NSF corporate days, special speaking engagements, individual meetings and luncheons.

Cost sharing policy

Q3. Please clarify the Foundation's interpretation of the Board's ruling on cost sharing.

Q3a. How has the Foundation's new policy (as defined by its interpretation of the Board ruling) been communicated to program officers?

A3a. Thank you for the opportunity to provide a clarification of the implementation of NSF's cost sharing policy. Since issuance of the NSF Cost Sharing Policy in 1999, this issue has continued to be widely discussed by the community, as well as within NSF and the National Science Board (NSB). Cost sharing was most recently addressed formally at the NSB's 382nd meeting in October, 2004, when the Board approved a revision to the Foundation's policy on cost sharing to eliminate NSF program-specific cost sharing requirements. The following highlights the essential elements of this Policy, as implemented by NSF:

- No NSF program solicitation may mandate a programmatic cost sharing requirement.
- There is no expectation by the Foundation that any proposal submitted for funding will include a cost sharing component. If a proposer voluntarily includes cost sharing on Line M of the proposal budget, it is solely at the discretion of the proposing institution and will not be a factor in the Foundation's decision to make an award. However, once cost sharing is proposed on Line M, and accepted by the Foundation, the commitment of funds becomes legally binding and is subject to audit.[1]
- NSF program officers must follow the *NSF Proposal & Award Policies & Procedures Guide* guidance which states that they may discuss with principal investigators the "bottom line" award amount, but may not [re] negotiate or impose cost sharing or other institutional commitments.
- Any reduction of 10 percent or more from the total award amount proposed should be accompanied by a corresponding reduction in the scope of the project.
- Cost sharing commitments contained in awards made prior to implementation of the revised cost sharing policy remain unchanged.
- Failure to provide the level of cost sharing reflected in the approved budget may result in termination of the NSF award, disallowance of costs and/or refund of award funds to NSF by the awardee.

The new cost sharing policy was originally communicated in October 2004 by issuance of initial implementation guidance (*www.nsf.gov/pubs/policydocs/cspolicy1004.pdf*). This was disseminated widely both externally as well as internally to NSF program staff. Since that time, this policy change has been presented internally to NSF staff at various training sessions, including the set of program management seminars provided 4–5 times per year, and has been a component of our external outreach presentations. In addition, NSF appropriations no longer contain a statutory (one percent) cost sharing requirement; therefore, statutory cost sharing is eliminated effective with awards made on or after June 1, 2007. Further guidance on the elimination of program-specific cost sharing and removal of the statutory (one percent) cost sharing requirement is provided in the recently issued *NSF Proposal & Award Policies & Procedures Guide,* which may be accessed at: *www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf07140*

[1] If proposed, the estimated value of any in-kind contributions should be included on Line M. An explanation of the source, nature, amount and availability of any proposed cost sharing also must be provided in the budget justification. Section .23 of OMB Circular A–110 describes criteria and procedures for the allowability of cash and in-kind contributions in satisfying cost sharing and matching requirements.

Q3b. Do you have any reason to believe that the new cost-sharing policy has not been uniformly implemented across the Foundation?

A3b. In March 2007, the Office of Inspector General (OIG) recommended that NSF program officers carefully review cost sharing information provided by awardees. NSF Senior management has implemented staff training that emphasizes the importance of reviewing cost sharing documentation.

Q3c. Are you still considering modifications to the new policy or has it been finalized?

A3c. At the March 2007 meeting of the National Science Board, the Committee on Strategy & Budget instituted an *ad hoc* working group to consider the impacts of the new policy (including any unanticipated consequences of the decision to eliminate programmatic cost sharing.) In addition, the Engineering Directorate is conducting a pilot with the Engineering Research Centers program solicitation. This solicitation does not impose a cost sharing requirement, but rather, requires that a partnership be demonstrated in the proposal. The results of this pilot and the findings of the working group will be presented at a future NSB meeting.

While there are no current plans to alter the NSF cost sharing policy, further deliberations may occur as a result of the activities noted above.

Questions submitted by Representative Ralph M. Hall

Engaging industry

Q1. Beyond the government wide initiatives in which NSF participates and the Engineering Research Centers, please give us examples of ways NSF engages industry to help identify and support its own internal research priorities.

A1. NSF routinely includes representatives of industry on its advisory committees. Industry representatives also serve as *ad hoc* reviewers. Currently two members of the National Science Board are from industry. NSF also has a number of initiatives with strong industry components. Involvement is more proscribed in some programs than others, but in general, the Foundation values and encourages industry collaboration wherever appropriate. Whether formal or informal, such engagement clearly informs NSF priorities. Here are a range of examples:

(1) Partnerships for Innovation (PFI)—

www.nsf.gov/funding/pgm_summ.jsp?pims_id=5261&from=fund

The goals of the PFI program are to: 1) stimulate the transformation of knowledge created by the research and education enterprise into innovations that create new wealth; build strong local, regional, and national economies; and improve the national well-being; 2) broaden the participation of all academic institutions and all citizens in NSF activities to meet the workforce needs of the national innovation enterprise; and 3) catalyze or enhance infrastructure necessary to foster and sustain innovation in the long-term. In order to pursue these goals, this program supports partnerships among academe, the private sector, and State/local/Federal Government that explore new approaches to support and sustain innovation.

(2) Industry/University Cooperative Research Centers (I/UCRCs)—

www.nsf.gov/funding/pgm_summ.jsp?pims_id=5501&from=fund

The I/UCRCs program develops long-term partnerships among industry, academe, and government. The centers are catalyzed by a small investment from NSF and are primarily supported by industry center members. Each center is established to conduct research that is of interest to both the industry and the center.

(3) Grant Opportunities for Academic Liaison with Industry (GOALI)—

www.nsf.gov/pubs/1998/nsf98142/nsf98142.htm

The GOALI initiative aims to synergize university-industry partnerships by making funds available to support an eclectic mix of industry-university links. Special interest is focused on opportunities for: (1) faculty, postdoctoral fellows, and students to conduct research and gain experience with production processes in an industrial setting, (2) industrial scientists and engineers to bring industry's perspective and integrative skills to academe, and (3) interdisciplinary university/industry teams to conduct long-term projects. This initiative targets high-risk/high-gain research.

(4) Shared Cyberinfrastructure—

NOTE: The Council on Competitiveness conducted a study "Partnering for Prosperity" June 2006, on behalf of NSF, to evaluate the experiences of industrial/commercial user organizations of high performance computing (HPC) resources at supercomputing centers receiving NSF funding. Forty companies participated in the study involving the supercomputing centers listed below. The study concluded that the partnership between the NSF Centers and the U.S. businesses ". . .clearly has been successful." A hardcopy of the report is available from the Office of Cyberinfrastructure.

- The *National Center for Supercomputing Applications* (NCSA) has maintained collaborative relationships with a broad set of industry partners for over 20 years through its Private Sector Program (PSP). At present, PSP partners include Abaqus, ACNielson, Boeing, Caterpillar, Deere, Dell, Eclipse Energy Inc., ExxonMobil, IBM, Innerlink, JPMorgan, Microsoft, Motorola, Research Triangle Institute and State Farm. As part of the program, partnerships support the operation of a large scale, heavily used HPC system for industrial users that has been upgraded in 2007. In addition, there are numerous sponsored applied research activities funded by the private sector partners. Firms fund activities to ensure they remain fully aware of developments in technologies which are one-to-five years out, as well as fund projects directed to the application of technologies with immediate or near-immediate benefits to the sponsoring firm.
- The *San Diego Supercomputer Center* (SDSC) engages with approximately 24 industrial partners in a variety of ways, but the most prominent ones are in regard to hardware, software, sponsored research, and research collaborations.
- The *Pittsburgh Supercomputing Center* (PSC) maintains collaborative research Technology Partnerships with many leading companies involved in High Performance Computing, including Cray, Intel, CFS, Seagate, and Panassas. Previously, PSC worked with several leaders in HPC including Compaq(HP), Thinking Machines, IBM and StorageTek. PSC also has a Corporate Affiliates program, designed to provide its industrial partners with expertise and services to enhance and support their technical computing capabilities.

(5) Computing Community Consortium (CCC)—

www.nsf.gov/funding/pgm_summ.jsp?pims_id=13658&org=CISE&from=home

The Directorate for Computer and Information Science and Engineering (CISE) will support this consortium as a community proxy for facilitating the conceptualization and design of promising infrastructure-intensive projects identified by the computing research community to address compelling scientific "grand challenges" in computing. The consortium is expected to be broad-based with members from higher education as well as other private and public sector organizations, including industry.

(6) Mathematical Sciences Research Institutes—

www.nsf.gov/funding/pgm_summ.jsp?pims_id=5685&org=DMS

Mathematical Sciences Institutes stimulate research in all of the mathematical sciences through thematic and residential programs, workshops, and access to distinctive resources. Each of the seven institutes offers visiting opportunities for researchers in various stages of their careers. Among them, one can find specific programs for industrial postdocs, summer programs involving graduate students with problems from industry, and discovery-based experiences with industry for undergraduates.

(7) Cyber Defense Testbed for Experimental Research (DETER)—

www.isi.edu/deter/index.html

DETER provides academic, government, and industrial scientists a safe environment to contain, model, and analyze malicious attacks—especially those that might result in catastrophic damage to public networks supporting critical infrastructure. Overall, approximately 30 percent of testbed users come from private industry ranging from small technology start up companies to large government contractors and private research labs. Industry partners include Juniper Networks Inc., Hewlett Packard, Sun Microsystems, Dell, Intel and NTT.

(8) Portia—Sensitive Information in a Wired World—

www.nsf.gov/dir/index.jsp?org=CISE; http://crypto.stanford.edu/portia/

The Portia project has developed new methods for the detection and prevention of Phishing attacks, an identity attack to which millions of U.S. users succumb every year. Mozilla provides software and professional staff, including technical support in the form of resident scientists at Stanford.

(9) Trustworthy Cyber Infrastructure for the Power Grid—

www.iti.uiuc.edu/TCIP.html

The project's goal is to improve the security of the power grid. The Electric Power Research Institute (EPRI), the research organization that supports the electric power industry, is a major contributor to the project.

(10) Materials Centers—

www.nsf.gov/funding/pgm_summ.jsp?pims_id=5295&from=fund

Materials Research Science and Engineering Centers (MRSECs) support shared experimental facilities, provide support to stimulate emerging areas of materials research, and have strong links to industry and other sectors. Involvement in MRSEC activities by industrial scientists and engineers benefits those organizations in ways such as providing access to the latest scientific discoveries and the joint design of research programs to address issues of mutual interest.

(11) Nanoscale Science and Engineering Centers (NSEC)—

www.nsf.gov/crssprgm/nano

Research at the nanoscale aims to advance the development of the ultra-small technology that will transform electronics, materials, medicine, environmental science, and many other fields. The centers provide coherence and a long-term outlook to U.S. nanotechnology research and education. The centers have strong partnerships with industry, national laboratories, and international centers of excellence.

(12) Science and Technology Centers (STC)—

www.nsf.gov/od/oia/programs/stc/

NSF's STC Integrative Partnerships Program supports discovery and innovation in the integrated conduct of research, education, and knowledge transfer. STCs foster partnerships that build a new collaborative culture among researchers and educators at all levels in academia, industry, government laboratories, and other organizations. STCs have an impressive record of research accomplishments, including timely transfer of knowledge and technology from the laboratory to industry and other sectors.

(13) Science of Learning Centers (SLC)—

www.nsf.gov/funding/pgm_summ.jsp?pims_id=5567&from=fund

SLCs are built around a unifying research focus and incorporate a diverse, multidisciplinary environment involving appropriate partnerships with academia, industry, international partners, all levels of education, and other public and private entities.

Questions for the submitted by Representative Daniel Lipinski

K–12 education

Q1. While I'm pleased to see the President's American Competitiveness Initiative proposes doubling research budgets, the education budget at NSF is seeing much smaller increases. This greatly worries me, especially when just last month the National Assessment of Educational Progress released results which found that nearly 40 percent of high school students scored below the basic level in math. Overall funding for K–12 programs in the FY08 request falls by nine percent from the FY07 CR level. The Math and Science Partnerships Program, and the Noyce Teacher Scholarship program, both of which address critical needs in K–12 education, would be level funded. In addition, the Course, Curriculum and Laboratory Improvement program, which is the core program in the Division of Undergraduate Education, is slowly decreasing in funding.

You state that "encouraging new investigators to become effective contributors to the science and engineering workforce is a critical goal for the NSF." Can you elaborate on how NSF hopes to accomplish this goal and reverse the downward trends we're witnessing when the budget request continues to under fund this crucial area?

A1. The FY 2008 funding request for NSF's K–12 programs (the Robert Noyce Scholarship Program, the Discovery Research K–12 program, and the Math and Science Partnership programs) increases from the FY 2007 level by about $10.0 million or 6.5 percent. The FY 2008 request for the Course, Curriculum and Laboratory Improvement program is level to the FY 2007 amount at $37.50 million.

NSF is encouraging new investigators to become effective contributors in several ways:

- Promoting the use of discovery-based learning, which is becoming an integral feature of these K–12 programs, transforming education research and practice.
- Increasing access to interactive data sets, simulations, and up-to-date research results, as well as the opportunity to interact with researchers, in K-12 classrooms and in complementary informal science education venues. Science, technology, engineering, and mathematics (STEM) education at all levels continues to benefit from information, communications, and other new technologies, with their potential for more engaging and inclusive learning and discovery.
- Developing alternative and diverse approaches to excellence in education and mentoring to build strong foundations and foster innovation to improve K–12 teaching, learning, and evaluation in STEM.

National Nanotechnology Initiative

Q2. NSF's contribution to the multi-agency National Nanotechnology Initiative (NNI) is increased in this request by $ 7 million (4.5 percent), including $3 million more in support of research on the environmental, health and safety (El–IS) aspects of nanotechnology. This field holds great promise; it is certainly one of the most rapidly developing, dynamic areas of current scientific research and commercial development. I believe it is critical that we expand our research into the potential risks while the field is still in its relative infancy.

Can you elaborate on what NSF is doing as it relates to nanotechnology research?

A2. NSF supports fundamental research, infrastructure, and education in all areas of nanoscale science and engineering (NSE), excluding research involving clinical testing. The NSE activities are guided by long-term objectives which may be used by industry, the community, and other agencies. NSF supports over 3,000 active awards and 24 large centers and trains over 10,000 students and teachers each year. The modes of support include single investigator, multi-disciplinary team, center, and network awards.

NSF's contribution to the multi-agency National Nanotechnology Initiative (NNI) encompasses the systematic understanding, organization, manipulation, and control of matter at the atomic, molecular, and supramolecular levels in the size range of one to 100 nanometers. NSF contributes to the goals and seven program-component areas (PCAs) outlined in the NNI Strategic Plan:

(1) Fundamental nanoscale phenomena and processes.

The FY 2008 Request includes $142.67 million for fundamental research and education connecting quantum and other nanoscale phenomena predictively across length and time scales with the macro properties of materials. Emphasis will be on: novel phenomena, quantum control, and basic engineering processes, biosystems at the nanoscale, converging science and engineering at the nanoscale, and multi-scale, multi-phenomena theory, modeling, and simulation at the nanoscale.

(2) Nanomaterials.

The FY 2008 Request includes $60.19 million for discovery of novel nanoscale and nanostructured materials, and improving the comprehensive understanding of the properties of nanomaterials (ranging across length scales and including interface interactions). Research on the discovery, understanding, and control of materials at the nanoscale will be critical to the development and success of innovative technologies, including communications, catalysts, energy, health care, and manufacturing.

(3) Nanoscale devices and systems.

The FY 2008 Request includes $51.10 million for R&D that applies the principles of nanoscale science and engineering to create novel, or to improve existing, devices and systems. A special focus will be on nanomanufacturing of active nanostructures and nanosystems. Nanoelectonics beyond silicon nanotechnology and complementary

metal-oxide superconductors (CMOS) research will explore ultimate limits to scaling of features and alternative physical principles for devices employed in sensing, storage, communication, and computation. Another focus will be on nano-informatics for better communication and nanosystem design. It includes defining the ontology of terms, interconnecting databases, using specific informatics tools, and connecting to bioinformatics.

(4) Instrumentation research for nanotechnology.

The FY 2008 Request includes $14.50 million for R&D to create new tools needed to advance nanotechnology research and commercialization, including next-generation instrumentation for characterization, measurement, synthesis, and design of materials, structures, devices, and systems. A special challenge is developing tools for measuring and restructuring matter with atomic precision, for time resolution of chemical reactions, and for domains of biological and engineering relevance.

(5) Nanomanufacturing.

The FY 2008 Request includes $26.90 million to support new concepts for high rate synthesis and processing of nanostructures, nanostructured catalysts, fabrication methods for devices, and assembling them into nanosystems and then into larger scale structures of relevance in industry and in the medical field. R&D is aimed at enabling scaled-up, reliable, cost effective manufacturing of nanoscale materials, structures, devices, and systems.

(6) Major research facilities and instrumentation acquisition.

The FY 2008 Request includes $31.62 million for establishment of user facilities, acquisition of major instrumentation, and other activities that develop, support, or enhance the scientific infrastructure for the conduct of nanoscale science, engineering, and technology research and development. It also supports ongoing operations of the National Nanotechnology Infrastructure Network (NNIN), Network for Computational Nanotechnology (NCN) and National Network for Nanomanufacturing. The investment will support facilities for 16 ongoing Nanoscale Science and Engineering Centers (NSEC).

(7) Societal Dimensions.

The FY 2008 Request includes $62.92 million, an increase of $3.90 million over FY 2007, for various research and other activities that address the broad implications of nanotechnology for society, including benefits and risks, such as:

- Research directed at environmental, health, and safety impacts of nanotechnology development and basic research supporting risk assessment of such impacts ($28.75 million).

  Research will address three sources of nanoparticles and nanostructured materials in the environment (in air, water, soil, biosystems, and working environment), as well as the non-clinical biological implications. The safety of manufacturing nanoparticles is investigated in four center/networks: NSEC at Rice University (evolution of manufacturing nanoparticles in the wet environment), NSEC at Northeastern University (occupational safety during nanomanufacturing), NSEC at University of Pennsylvania (interaction between nanomaterials and cells), and National Nanotechnology Infrastructure Network (with two nanoparticle characterization centers at the University of Minnesota and Arizona State University). New measurement methods for nanoparticle characterization and toxicity of nanomaterials will be investigated. Support is requested for a new multi-disciplinary EHS center as explained in the reply to the next question.
- Education-related activities, such as development of materials for schools, curriculum development for nanoscience and engineering, development of new teaching tools, undergraduate programs, technical training, and public outreach ($28.38 million).

  Two networks for nanotechnology education with national outreach will be supported: The Nanotechnology Center for Learning and Teaching (NCLT) and the Network for Nanoscale Informal Science Education (NISE).
- Research directed at identifying and quantifying the broad implications of nanotechnology for society, including social, economic, workforce, educational, ethical, and legal implications ($5.79 million).

  Factors that stimulate scientific discovery at the nanoscale will be investigated, effective approaches to ensure the safe and responsible development of nanotechnology will be explored and developed, and the potential for con-

verging technologies to improve human performance will be addressed. The Nanotechnology in Society Network will be fully operational in FY 2008.

NSF has an annual process of establishing its priorities on nanoscale science and engineering that includes NNI Working Group proposals with input from periodical workshops and meetings with the communities, coordination with other agencies through the National Nanotechnology Initiative (the Nanoscale Science, Engineering and Technology Subcommittee (NSET) of the National Science and Technology Council (NSTC)), considering the international context, industry, NGOs, and other perspectives.

Q3. Can you expand on the proposed new, multi-disciplinary center that would conduct EHS research?

A3. The National Science Foundation is in the process of preparing a program announcement for a new Nanoscale Science and Engineering Center (NSEC) on "Nanotechnology Environmental Health and Safety" to be released later this year. This will be a NSF wide activity coordinated by the Directorate for Biological Sciences. It is planned to create education, outreach, and communication between the main stakeholders.

Manufactured nanomaterials and their byproducts may display new physical, chemical, or biological properties unique to materials of this small size (i.e., one to 100 nanometers). The purpose of this multi-disciplinary center will be to conduct fundamental research and education on the interactions of nanoparticles and nanomaterials in and with the environment (air, water, and soil) and living systems at all scales in order to understand and address the potential impact of nanotechnology on the environment and living systems. A multi-disciplinary approach involving the biological, physical, computational, and mathematical sciences will be employed to understand how nanomaterials and their byproducts interact with and impact the environment and living systems at all scales. Research will include but is not limited to methods and instrumentation for nanoparticle detection, characterization, and monitoring; interactions of nanomaterials with cellular constituents, metabolic networks, and living tissues; bioaccumulation and its effects on living systems; and the non-medical biological impacts of nanostructures dispersed in the environment. In addition to understanding the potential impact of nanomaterials on environmental health and safety, this research also is expected to yield reciprocal knowledge on how characteristics unique to the nanoscale realm play a role in natural systems and their design.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Steven C. Beering, Chairman, National Science Board

Questions submitted by Chairman Brian Baird

Q1. Please clarify the Board's intent with respect to the Foundation's policy on cost-sharing. Is the Board considering revisiting its ruling and/or evaluating the implementation and impact of the ruling on programs across the Foundation?

A1. The National Science Board has been involved with "cost sharing" since the Bureau of the Budget's (predecessor of the OMB) 1954 request for assistance in setting uniform policies for indirect costs for research grants from federal agencies.

The Board addressed cost sharing on a number of occasions since 1954 in regard to implementation of the 1963 statutory cost sharing requirements, university concerns over the logistics of calculating cost share contributions, and the effect cost share would have on wealthy and not so wealthy schools, public and private institutions, and between basic and applied research.

In October 2004, NSF requested a revision to the current Board policy on cost sharing to eliminate NSF program specific cost sharing requirements and require only the statutory cost sharing of one percent. The Board approved that request on the recommendation of its Audit and Oversight Committee. The Board recently decided to establish an ad hoc task group within its Committee on Strategy and Budget to study cost sharing policies of the Foundation. The task group's activities will take into account the Foundation's legal requirements, impact of previous cost sharing policies, and the practice and implementation of those policies. Specifics about the Board's likely actions will become clearer as the task group conducts its study and the Board considers the task group's findings and recommendations.

Questions submitted by Representative Ralph M. Hall

Q1. Is the Board engaged in encouraging industry partnerships? To what degree?

A1. The Board believes industry should be a full partner with government, academe, the non-profit sector and the public in maintaining the health of U.S. science and engineering research and education. Industry is by far the largest employer of scientists and engineers and the largest source of funding for U.S. R&D. Partnership with industry in policy decisions affecting the science and engineering enterprise is critically important and highly sought after by the Board and Foundation. Further, we fully endorse and support industry partnerships with academic institutions in education and research funded by the National Science Foundation. The Board membership throughout its history has included industry representation in order to reflect the leadership of U.S. science and engineering. The Board also provides explicit policy for NSF to initiate programs that include industry partnerships in research and education. For example, the Board's 1996 policy statement, "Report from the Task Force on Graduate and Post Doctoral Education" (NSB/NGE–96–2) provided the policy framework for implementation in FY 97 of alternative modes of graduate support "permitting internships in industry. . .as part of the graduate research experience." Programs such as Integrative Education and Research Training (IGERT) have been implemented by the Foundation to encourage this form of academic/industry partnering. The Board further supports partnerships and collaboration in research and education in NSF funded centers, and in programs such as the Math and Science Partnerships. These large awards are directly approved by the Board after careful review, including the industry partnership components, and followed up by assessments of success. Renewal of such major grants and cooperative agreements often depends significantly on success in attracting industry partners, and on the level of involvement of such partners.

The Board also solicits the input of industry in the formulation of policy for science and engineering, both as guidance to the Foundation and as advice to the President and Congress. Recent examples include Board hearings to consider the establishment of a new Commission on 21st Education in Science, Technology, Engineering and Mathematics; the Board's ongoing study of Engineering Education needs for the future, and the 2003 Board policy report, *The Science and Engineering Workforce: Realizing America's Potential* (NSB–03–69) *<http://www.nsf.gov/nsb/documents/reports.htm>*. The Board's biennial report on Science and Engineering Indicators includes an increasingly broad component of industry relevant quantitative data, and the NSF industry survey is in the process of being redesigned in order to improve data for decision making involving industrial science and technology. We further support grants under the SBIR and STTR programs in the Foun-

dation (Small Business innovation Research and Small Business Technology Transfer, respectively). We expect industry partnerships to continue to be an essential component of projects and policy for science and engineering in the Foundation and an important policy focus for the National Science Board.

Questions submitted by Representative Daniel Lipinski

Q1. In your testimony, you mention NSF's involvement with energy research as a partner in the President's hydrogen fuel initiative through membership in the Interagency Hydrogen and Fuel Cell Technical Task Force. As you may know, I, along with Representative Inglis, am a big advocate for hydrogen technology, having reintroduced the popular H–Prize bill this Congress. Can you elaborate on this Task Force, and give us a sense of what it has accomplished and the results that have come out of it?

A1. The Interagency Hydrogen and Fuel Cell Technical Task Force was established shortly after President Bush announced the Hydrogen Fuel Initiative and has met monthly since April 2003. It serves as the key mechanism for collaboration among the federal agencies involved in hydrogen-related research, development, and demonstration. As specified in Section 806 of the *Energy Policy Act of 2005* (P.L. 109–58), the Task Force provides a forum for coordinating interagency policy, programs, and activities related to safe, economical, and environmentally sound hydrogen and fuel cell technologies. Co-chaired by the Department of Energy (DOE) and White House Office of Science and Technology Policy (OSTP), the task force includes the Department of Transportation; Department of Defense; Department of Agriculture; Department of Commerce; Environmental Protection Agency; National Aeronautics and Space Administration; National Science Foundation; United States Postal Service; and, from the Executive Office of the President, Office of Management and Budget, and Council on Environmental Quality. More information is available at (*http://www.hydrogen.gov/interagency_task_force.html*).

The task force ad hoc committee on a regulatory framework for a hydrogen economy has identified existing and regulatory statutory authorities, status of regulations, gaps in authority, and the lead agency. All of this information has been integrated into an interactive map complete with references to each applicable regulation or statute (see *www.hydrogen.gov/regulations.html*).

The task force agriculture ad hoc committee is developing an action plan with specific coordination activities for biomass-to-hydrogen and fuel cell technology development and use in rural communities.

There are a number of areas where the hydrogen fuel cell interagency working group (IWG) has led to interagency collaboration on particular topics, such as materials research, hydrogen turbines, and solid-state fuel cells.

Over the past four years, the IWG has collaboratively identified R&D gaps that have merited additional focus, including hydrogen infrastructure R&D, bio-based H2 production, and directed basic research on fuel cells, hydrogen storage, and hydrogen production.

The task force created extensive hydrogen research taxonomy of past, present, and future hydrogen activities of the Federal Government. More information may be found at *http://www.hydrogen.gov/taxonomy.html* and *http://www.hydrogen.gov/federalprograms.html*

The agencies are also working to establish a "higher level" task force with members at the Assistant Secretary level or functional equivalent to advise the Secretary of Energy on issues related to the development and use of hydrogen technologies. The task force will not replace the IWG—it is fully expected to that the groups will complement and support each other.

Q2. You also mention NSF's Energy for Sustainability Program, which will fund basic research and engineering of hydrogen and other alternative fuel systems. Please explain this program and what it is doing in the field.

A2. NSF's Engineering Directorate established the Energy for Sustainability Program to consider a wide variety of topics and encourage investigator-initiated projects to capture the best and brightest in the engineering of energy for the future. The emphasis will be on research and education in energy production, conversion, and storage for energy sources that are environmentally friendly and renewable.

The program is aimed at university researchers involved in basic or fundamental engineering research to advance renewable energy sources. Small business ventures are also eligible to apply to the Small Business Innovation Research (SBIR) program

at NSF. Larger firms can participate in if they team with a researcher from a university through Grant Opportunities for Academic Liaison with Industry (GOALI).

The FY 2007 budget is $3 million. This is a new program and therefore no awards have been made, but over 200 unsolicited proposals were received in response to the February 2007 program announcement. The majority of these proposals involved fuel cells, biofuels, or solar energy. Awardees for this round are expected to be selected and announced by August 1, 2007. A second program announcement is scheduled for August–September 2007. The program intends to fund approximately 20 projects having budgets of around $100,000 per year for two or three years.

In addition, two researchers are being funded under NSF's Faculty Early Career Development (CAREER) Program for work on sustainable energy involving direct methanol and microbial fuel cell concepts.

NATIONAL SCIENCE FOUNDATION REAUTHORIZATION: PART II

THURSDAY, MARCH 29, 2007

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

The Subcommittee met, pursuant to call, at 2:57 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Brian Baird [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUITE 2320 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6301
(202) 225-6375
TTY: (202) 226-4410
http://science.house.gov

The Subcommittee on Research and Science Education

Hearing on:

"National Science Foundation Reauthorization: Part II"

2318 Rayburn House Office Building
Washington, D.C.

Thursday, March 29, 2007
2:00 p.m.

WITNESS LIST

Dr. Phyllis M. Wise
Provost
University of Washington, Seattle

Dr. Catherine T. Hunt
President
American Chemical Society

Dr. Margaret F. Ford
President
Houston Community College System, Northeast

Dr. Carlos A. Meriles
Assistant Professor of Physics
The City College of New York- CUNY

Dr. Jeffrey J. Welser
Director of the Nanoelectronics Research Initiative
Semiconductor Research Corporation

HEARING CHARTER

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

National Science Foundation Reauthorization: Part II

THURSDAY, MARCH 29, 2007
2:00 P.M.—4:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Thursday, March 29, 2007, the Subcommittee on Research and Science Education of the House Committee on Science and Technology will hold a hearing to receive testimony from various stakeholders in the scientific and technical community regarding pending legislation to reauthorize core activities, amend administrative laws and set new policy directions for NSF.

2. Witnesses

- **Dr. Catherine T. (Katie) Hunt,** President, American Chemical Society
- **Dr. Phyllis M. Wise,** Provost, University of Washington, Seattle
- **Dr. Margaret L. Ford,** President, Houston Community College System–Northeast
- **Dr. Carlos A. Meriles,** Assistant Professor of Physics, City College of New York
- **Dr. Jeffrey J. Welser,** Director of the Nanoelectronics Research Initiative, Semiconductor Research Corporation

3. Overarching Questions

- What is the appropriate balance between funding for interdisciplinary and disciplinary research? What are the best mechanisms for soliciting and funding interdisciplinary proposals? Is NSF doing a sufficient job of publicizing opportunities for funding in interdisciplinary research?
- The average success rate across the directorates is significantly lower for new investigators than for investigators previously funded by NSF. What can NSF do to narrow that gap? In particular, what funding mechanisms make the most sense without undermining the merit-review process, and what additional steps can NSF take to nurture young investigators?
- What incentives exist for industry to help fund research and education programs at NSF? What is NSF doing to foster industry/university partnerships outside of the few programs designed specifically for that purpose?
- Is undergraduate science, technology, engineering and mathematics (STEM) education keeping pace with changing paradigms in scientific understanding and practice? With workforce needs? What is the most important role for NSF in undergraduate education?

4. Brief Overview

- NSF currently has a budget of $5.9 billion and is the funding source for approximately 20 percent of all federally supported basic research conducted by America's colleges and universities. NSF also supports programs to improve U.S. STEM education and increase participation in STEM fields at all levels and in all settings. (For additional background information on NSF and the fiscal year 2008 budget, refer to the charter from the March 20 hearing on NSF Reauthorization: Part I, available at *http://science.house.gov/*)

- NSF is a proposal-driven (bottom-up) agency that operates almost exclusively by competitive merit-review. Reviewers are asked to evaluate proposals based on two criteria: What is the intellectual merit of the proposed activity; and what are the broader impacts of the proposed activity?
- Breakthroughs in science and technology that will have a near- to mid-term impact on society are increasingly requiring interdisciplinary teams of scientists and engineers willing and able to cross their traditional disciplinary boundaries. NSF has begun to react to the pressure from the community to re-evaluate its role in interdisciplinary research and education, but has not yet articulated a coherent path forward.
- New investigators have a 17 percent funding success rate, compared to a 28 percent success rate for prior investigators and an overall rate of 23 percent. The CAREER grant program was established explicitly to help find and fund outstanding young investigators, but CAREER awards differ from standard NSF awards in size, duration and evaluation criteria.
- There are specific programs at NSF, such as the Engineering Research Centers and the Industry/University Cooperative Research Centers, in which industry partnership is a requirement. However, opportunities exist outside of those programs for businesses to partner with university researchers in areas of basic research directly relevant to those businesses' needs. The Nanoelectronics Research Initiative is one example of such a partnership.
- There are four main undergraduate-focused STEM programs at NSF (not including K–12 teacher training programs): a research experience program funded by the research directorate; and one curriculum development program and two workforce development programs funded by the education directorate.

5. Issues

Interdisciplinary research

"Training individuals who are conversant in ideas and languages of other fields is central to the continued march of scientific progress in the 21st century."[1] NSF, like all federal research agencies, is already funding interdisciplinary research. There are several cross-directorate and in some cases multi-agency programs, including: Cyber-enabled Discovery and Research (a new program for FY 2008), Cyberinfrastructure, Networking and Information Technology R&D (NITRD), and the National Nanotechnology Initiative (NNI), to name a few. The majority of NSF-funded Centers are also staffed by multi-disciplinary teams of scientists, engineers and educators. In addition, individual directorates have their own interdisciplinary and multi-disciplinary coordinating activities. For example, the Mathematical and Physical Sciences Directorate has a separate Office of Multi-disciplinary Activities, which facilitates, coordinates and co-funds multi-disciplinary and interdisciplinary activities between divisions, but does not directly manage any grants.

There is no standard definition for the term "interdisciplinary research." Furthermore, there is no standard delineation between interdisciplinary, multi-disciplinary and cross-disciplinary. In 2004, the NAS Committee on Science, Engineering and Public Policy issued a report on *Facilitating Interdisciplinary Research.* After reviewing the wide range of definitions in use, the NAS report panel settled on the following: "Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice." The panel distinguished between multi-disciplinary and interdisciplinary as follows: Multi-disciplinary teams join together to work on common problems, but may split apart unchanged when the work is done, while interdisciplinary teams may end up forging a new research field or discipline.

The issue of facilitating interdisciplinary research and pushing the frontiers of 21st Century science without compromising the potential for advances in disciplinary research or educating a generation of scientists and engineers without depth of knowledge in any single field is a complex and controversial one. Nevertheless, it is an issue at the forefront of the scientific enterprise and one that NSF and the rest of the scientific enterprise is struggling with.

Outside of the standing cross-directorate programs listed previously, most of the directorates process unsolicited interdisciplinary proposals from the bottom-up. This

[1] Robert Day, CEO of the Keck Foundation.

is a largely ad hoc process by which individual program officers receive proposals that they identify as interdisciplinary, decide to approach the program officer(s) in the appropriate division(s) relevant to the proposal, and work as a team to manage the review process, including putting together a review panel compromised of experts from all of the relevant fields. In some cases, instead of co-equal proposal managers, there may be a "principal" program officer with the others serving as advisors. There is no standard policy for handling interdisciplinary proposals across NSF. Whether or not it makes sense to institute a Foundation-wide policy rather than leaving the details to the heads of the directorates, NSF should be more clear in general about how they will balance interdisciplinary and disciplinary research moving forward, and they need to make clear to the scientific community how unsolicited interdisciplinary proposals are handled.

Young investigators

In the National Science Board's 2005 report on the NSF merit review process, they found that new investigators have a 17 percent funding success rate, compared to a 28 percent success rate for prior investigators and an overall rate of 23 percent. The Board identified the new versus prior investigator gap to be the "major gap" in success rates, while other demographic subgroups—in particular, women and minorities—were right at or even above the Foundation average.

The CAREER grant program was established explicitly to help find and fund outstanding young investigators, but CAREER awards differ from standard NSF awards in size, duration and evaluation criteria. In particular, there is an emphasis on the integration of research and education, which is not a required evaluation criterion for standard NSF research grants. The minimum CAREER award size is $400,000 for a five-year period. NSF-wide, the average annualized award amount for research grants in FY 2005 was $143,600, and the average duration is three years (range: 1–5 years).

Small Grants for Exploratory Research (SGER) awards were established in 1990 for small-scale grants awarded at the discretion of the program officers and without formal external review. NSF made 387 SGER awards in FY 2005 for a total of $27 million, and with an average size of $70,000. SGER awards are made, among other things, for preliminary work on untested ideas, and ventures into emerging research and potentially transformative ideas. Providing new investigators with seed money to make their proposals more competitive, for example with SGER funds, is one possible mechanism to help narrow the gap in success rates. Program officers may also be encouraged to take an active role in mentoring new investigators through the proposal and review process.

High-risk research

There is another potential benefit to NSF taking a more active role in supporting new investigators. Young investigators, on average, are more likely to take risks in their research than more established researchers. They don't yet have a base from which to build incrementally, they don't yet have a large cadre of graduate students, post-docs and other lab personnel to support, and perhaps they are more willing and able by nature to think outside the box and take risks.

The National Science Board has called for a Foundation-wide transformative research initiative. The Board defines transformative research as "research driven by ideas that stand a reasonable chance of radically challenging our understanding of an important existing scientific or engineering concept or leading to the creation of a new paradigm or field of science or engineering. Such research is also characterized by its challenge to current understanding or its pathway to new frontiers." It is not clear what such an initiative would look like or how it would be carried out, but there is general agreement in the community that merit review panels are conservative by nature and that more effort needs to be made to fund high-risk research. Putting more effort into supporting young investigators is just one approach to addressing this need.

Industry partnerships

A primary mission of NSF is to create new knowledge and understanding, not to develop technology. More often than not, there is no immediately obvious application for the basic research funded by NSF. However, there is also a range of research—in materials science, computer science, physics, chemistry—that may in fact have near-term applications that go unidentified. Unfortunately, there is a big cultural divide between academic researchers, who produce the knowledge, and private sector engineers, who identify useful applications for that knowledge. Both groups are

typically wholly uninterested in what the other is doing and there are few mechanisms or forums to facilitate interaction and collaboration.

There are a few programs at NSF that explicitly require university/industry partnerships. Two of those programs, the Industry/University Cooperative Research Centers (I/UCRC) and the Grant Opportunities for Academic Liaison with Industry (GOALI) are housed in the newly formed Industrial Innovation and Partnerships (IIP) division of the Engineering Directorate, and total just over $11 million in FY 2007. (That division also funds the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, which do not require university participation.) Outside of IIP, the main program with this goal is the Engineering Research Centers (ERCs) program, which is funded at $63 million in FY 2007. A number of other NSF-funded Centers also have strong ties to industry because of the nature of the research. Centers also happen to be one of the primary mechanisms for the funding of interdisciplinary research at NSF. However, NSF does not have an agency-wide mechanism for connecting academic researchers with potential industry partners.

Education and Workforce

The Education and Human Resources (EHR) Directorate at NSF supports STEM education and workforce training programs at all levels and in all settings. EHR also has several programs to increase participation in STEM fields at all levels. K–12 STEM education has been the focus of several recent Science and Technology Committee bills and hearings. The witnesses at today's hearing were asked to focus on undergraduate STEM education, including at two-year colleges, where much of the 21st Century workforce is educated and trained.

The undergraduate education programs funded by NSF (and not tied to K–12 teacher education) are the Course, Curriculum, and Laboratory Improvement (CCLI) program, the Advanced Technological Education (ATE) program and the STEM Talent Expansion Program (STEP). In addition, the research directorate funds the Research Experience for Undergraduates (REU) program.

The CCLI program funds the development of new learning materials, faculty expertise, and assessment and evaluation. It is the core program in the Undergraduate Education division and is funded at $34 million in FY 2007. The STEP program supports colleges and universities to increase the number of students receiving associate or baccalaureate degrees in STEM fields, and is funded at $25 million in FY 2007. The ATE program, which is focused at two-year colleges, supports improvement in technician education in the science- and engineering-related fields that drive the Nation's economy. It is funded at $45 million in FY 2007. The REU program, funded at $57 million in FY 2007, supports active research participation by undergraduate students in any area of research funded by NSF. It particularly targets students from those institutions where research programs are limited—sending them to host institutions that have stronger research programs.

6. Questions for Witnesses

In their invitations to testify before the Subcommittee, witnesses were asked to discuss any specific suggestions or concerns that they may have regarding the draft legislative section-by-section summary provided to them. In addition, they were asked to address the following questions in their testimony:

Dr. Hunt, American Chemical Society

- What role does ACS, and can scientific societies generally, play in nurturing and supporting young investigators? In building university/industry partnerships?
- Is NSF doing an adequate job of supporting and mentoring young investigators? Of facilitating industry/university partnerships? Of establishing research priorities based on national needs? Of communicating opportunities for funding of interdisciplinary research? Do you have any specific suggestions on how NSF might modify their efforts on any of these fronts?
- What is the most important role that NSF can play in undergraduate science and technology education, including at two-year colleges? Is the Foundation doing an adequate job of filling that role? Do you have any specific suggestions of how NSF might do things differently with respect to undergraduate education?

Dr. Wise, University of Washington

- How do new investigators at your university fare in getting NSF research grants? Does the university administration have any policies or mechanisms in place to assist your young faculty in securing funding or are those efforts strictly department-driven? Do you have any suggestions as to what NSF may do differently to improve funding success rates for new investigators?
- Please describe your university's relationship with local industries. How does the university administration help connect your faculty with local business entrepreneurs and leaders? Do you keep track of industry cost-share on NSF grants? Do you have any suggestions as to what NSF may do differently to facilitate university/industry partnerships at major research universities?
- What is the appropriate balance between funding for interdisciplinary and disciplinary research? What models or frameworks for interdisciplinary research seem to work best at your university? Is NSF doing a sufficient job of publicizing opportunities for funding of interdisciplinary proposals to your faculty?
- Please describe the process by which undergraduate science, technology, engineering and mathematics (STEM) curricula at your at your university are reviewed and updated as necessary in response to shifting paradigms in these fields. What role does NSF play in this process? Do you have any suggestions as to what NSF may do differently to assist universities in maintaining world class undergraduate STEM education?

Dr. Ford, Houston Community College System–Northeast

- Please provide a brief overview of science, technology, engineering and technician training programs at your community college, including partnerships with local industries and how many students you reach through these programs.
- Please describe the NSF-funded Advanced Technological Education (ATE) program at your community college. What are the markers of its success? How might you improve the program? Based on your experience, do you have any specific suggestions for NSF on how to improve its ATE program?
- Does your community college system have a relationship with NSF outside of the ATE program? Do you believe that NSF is adequately serving the science and technology education and research needs of U.S. community colleges? Other than providing more money, what might NSF do differently or better to serve community college needs?

Dr. Meriles, City University New York

- Is the National Science Foundation (NSF) doing an adequate job of supporting and mentoring young investigators? Do you have any specific suggestions on what NSF might do differently to increase funding success rates for young investigators?
- Did you encounter any difficulties in applying for an NSF CAREER award? What kind of post-award interactions do you have with NSF officials? Do you have any specific recommendations for changes to the CAREER program?
- As an investigator involved in basic research that has direct relevance to industry needs—in this case the semiconductor industry—how would you go about establishing contact with companies that might be interested in your work? Have you or would you turn to NSF to help facilitate such conversations?

Dr. Welser, Nanoelectronics Research Initiative

- Please describe the relationship between the Nanotechnology Research Initiative and NSF. How did this relationship get started?
- Why is the semiconductor industry helping to fund basic research at universities? What benefits have you already seen or do you anticipate to your own industry's competitiveness?
- What advice would you provide to other industries and/or to universities about building industry/university partnerships? What advice would you provide to NSF about facilitating such partnerships?

- As has been stated in so many recent reports, preparing the workforce of the 21st Century requires starting at the beginning of the pipeline—with K–12 science, technology, engineering and mathematics (STEM) education. What is the most important role that industry can play in efforts to improve U.S. K–12 STEM education? What about undergraduate education, in particular at two-year colleges?

Chairman BAIRD. Everyone, I appreciate your patience. We had, as you know, a budget vote on the Floor, and depending on your party perspective, it may not have been a good outcome, but from my perspective, it was great, and I think from the perspective of science and education, it wasn't half bad either.

I want to thank all our witnesses for being here, and with the arrival of my dear friend, Vern Ehlers, this meeting will come to order.

We have an outstanding panel today, and Vern and I were talking about this with other Members. We are just thrilled that you are here, and looking forward to your comments. This is the second of hearings on our Research and Science Education Subcommittee on legislation to reauthorize programs at the National Science Foundation.

Last week, we heard testimony from agency officials, and today, we will hear from an outstanding panel representing diverse interests and expertise in the scientific research and education communities, including a major research university from my home state, a community college with extensive technical education programs, a major scientific society, a recipient of NSF's prestigious Career Award for new investigators, and an industry research consortium that partners closely with university researchers through various NSF programs. I think it is just an optimal accumulation of individuals of great talent, and we are just delighted you are here.

So, rather than repeating everything I said at our first hearing, last week, with Dr. Bement and Dr. Beering, I will just outline the main themes that we are seeking input on as we proceed with development of the legislation, and I think you have all been briefed a little bit about some of those themes.

One of our questions is how can NSF best exploit and lead the trend toward interdisciplinary research without sacrificing core strengths in single investigator disciplinary research? Second, what can NSF do to help keep talented young investigators in the research pipeline, in particular, to improve funding success rates for new investigators?

Third, what can NSF do to help facilitate industry/university partnerships across the Foundation? And finally, although certainly not the least, what is the most appropriate role for NSF in undergraduate STEM education, including at two year colleges, and I would note in that regard that just, was it yesterday we passed, or the day before, Chairman Gordon's legislation regarding science and math education, a very strong vote from the Committee, and we are excited about where that will go.

In addition to soliciting the panel's input on these broad themes, we welcome your comments, suggestions, in response to the legislative summary we have provided to you along with the invitation to testify. As I stated last week in our hearing, I want the process of developing the NSF reauthorization bill to be open, transparent, and responsive to all concerned parties, both within and outside the government. I encourage you to be in touch with me and my staff, even outside the formal setting of this hearing.

[The prepared statement of Chairman Baird follows:]

PREPARED STATEMENT OF CHAIRMAN BRIAN BAIRD

Good afternoon. I want to welcome you to the second of two Research and Science Education Subcommittee hearings on legislation to reauthorize programs at the National Science Foundation.

Last week we heard testimony from agency officials. Today we will hear from an outstanding panel representing diverse interests and expertise in the scientific research and education communities—including a major research university, a community college with extensive technical education programs, a major scientific society, a recipient of NSF's prestigious CAREER award for new investigators, and an industry research consortium that partners closely with university researchers through various NSF programs.

Rather than repeating everything I said at our first hearing last week with Dr. Bement and Dr. Beering, I will just outline the main themes that we are seeking input on as we proceed with development of the legislation.

First, how can NSF best exploit and lead the trend toward interdisciplinary research without sacrificing its core strengths in single-investigator disciplinary research?

Second, what can NSF do to help keep talented young investigators in the research pipeline, and in particular, to improve funding success rates for new investigators?

Third, what can NSF do help facilitate industry/university partnerships across the Foundation?

Last, although certainly not least, what is the most appropriate role for NSF in undergraduate STEM education, including at two-year colleges?

In addition to soliciting the panel's input on these broad themes, we welcome your comments and suggestions in response to the legislative summary we provided to you along with the invitation to testify. As I stated last week, I want the process of developing the NSF reauthorization bill to be open, transparent and responsive to all concerned parties both within and outside of government. I encourage you to be in touch with me and my staff even outside the formal setting of this hearing.

Chairman BAIRD. Before introducing our distinguished panel of witnesses, I would be happy to yield to my distinguished colleague, Ranking Member Dr. Ehlers, for his opening remarks. Dr. Ehlers?

Mr. EHLERS. Thank you, Mr. Chairman. I apologize for being a bit late. I had to wait on the Floor to see if they were going to revote the adjournment resolution. This is sort of an in-joke. We have been revoting a lot of votes lately.

I am pleased to participate in the Research and Science Education Subcommittee's second hearing addressing the reauthorization of the National Science Foundation, truly one of the finest agencies this government has ever had.

Today, our witnesses represent the diversity of constituents who work with the NSF, showing the broad impact of this agency. Pervasive across the witness' prepared testimony is recognition of the need to further define the educational role of the National Science Foundation. Everyone here today knows that the Education and Human Resources Directorate has suffered funding stagnation and cuts, even while the research budget of NSF is considered a national priority for U.S. competitiveness and innovation, and subsequently increased. It is clear to me that you cannot separate the research and education mission of NSF, and I would like to explore ways to ensure that we reverse the discouraging trend of the past few years.

Related to education, I am also pleased that the role of NSF in undergraduate education is receiving special attention in this hearing. An institution in my own district, Calvin College, at which I previously taught, has taken steps to help their student researchers appreciate the impact of NSF on their work by requiring all equipment obtained with the help of NSF to include a small label

stating: "The National Science Foundation supported the purchase of this equipment." Students, and I might add, their parents, become acquainted with a sometimes invisible benefactor.

I applaud Calvin for such a small, but significant step in communicating the critical support the National Science Foundation supplies to primarily undergraduate institutions. That said, grants made to undergraduate institutions have been stretched especially thin in recent years, due to the inadequate funding in this area. I know this committee is considering healthy levels of authorization for undergraduate education, and I will definitely work to see those levels achieved through appropriations.

Another issue before the Committee within reauthorization is how to encourage NSF to capture more researchers at early stages of their careers. Our panel today includes Professor Meriles, a physicist from the City College of New York, which also has some very distinguished alumni in the audience, I believe.

He represents, in many ways, both the challenges and successes of young investigators today, and I am very interested in learning about his experiences as one of the few selected recipients of NSF's Faculty Early Career Development grants. Finding ways to reward creative thinking, a characteristic of young researchers, is critical to ensure that NSF continues to produce the many unanticipated applications of fundamental research.

I certainly want to thank our witnesses for being here today. It is a very distinguished panel. I was pleased to read about your backgrounds. I am sure you will add greatly to our store of knowledge today, as we continue our efforts to improve the National Science Foundation.

Thank you very much.

[The prepared statement of Mr. Ehlers follows:]

PREPARED STATEMENT OF REPRESENTATIVE VERNON J. EHLERS

I am pleased to participate in the Research and Science Education Subcommittee's second hearing addressing the reauthorization of the National Science Foundation. Today our witnesses represent the diversity of constituencies who work with the NSF, showing the broad impact of this agency.

Pervasive across the witnesses' prepared testimony is recognition of the need to further define the educational role of NSF. Everyone here today knows that the Education and Human Resources Directorate has suffered funding stagnation and cuts, even while the research budget of NSF is considered a national priority for U.S. competitiveness and innovation and subsequently increased. It is clear to me you cannot separate the research and education mission of NSF, and I would like to explore ways to ensure that we reverse such a discouraging trend.

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selected recipients of NSF's Faculty Early Career Development (CAREER) grants. Finding ways to reward creative thinking characteristic of young researchers is critical to ensure that NSF continues to produce the many unanticipated applications of fundamental research.

I thank our witnesses for being here today and look forward to their testimony.

Chairman BAIRD. Thank you very much, Dr. Ehlers, and I share your—how impressed we both are with the witnesses.

[The prepared statement of Mr. Carnahan follows:]

PREPARED STATEMENT OF REPRESENTATIVE RUSS CARNAHAN

Mr. Chairman, thank you for hosting this second hearing on reauthorizing the National Science Foundation (NSF).

NSF is the funding source for about 20 percent of federally-supported basic research conducted at U.S. universities. In my home district, Washington University in St. Louis is a major recipient of NSF awards. I am proud of the great research conducted there as well as in other institutions in our region.

Two weeks ago, this subcommittee heard from the NSF leadership on what they believe needs to be addressed during the reauthorization process. I am particularly interested in hearing what those of you who work with NSF think, and I am grateful to you for taking time out of your busy schedules to travel here and speak with us today.

I know most of you have been asked to address the role of NSF in undergraduate STEM education, how we can encourage young investigators and foster partnerships between universities and industry. I believe all of these issues are tremendously important to improving our nation's competitiveness and very much look forward to hearing your thoughts on these specific issues.

Again, thank you for being here today and I look forward to hearing your testimony.

Chairman BAIRD. We will give very brief biographies. There is no possible way to do justice. We would be far exceeding our hearing time, if I were to do justice to your resumes.

Dr. Phyllis Wise is the Provost and Vice President for Academic Affairs at the University of Washington, the Pacific Northwest's biggest research university. We are very proud of the University of Washington's achievements. In her free time, she is a Professor of Physiology, and Biophysics, Biology, and Obstetrics and Gynecology, in addition to her work as Provost. Dr. Wise, thank you for being here.

Dr. Catherine "Katie" Hunt is the President of the American Chemical Society, and Leader for Technology Partnerships for Rohm & Haas Company. Dr. Hunt, thank you.

Dr. Margaret Ford is President of Houston Community College System, Northeast, and serves on the board of the American Association of Community Colleges. As a former both university and community college instructor myself, I am thrilled that we have community college representation here.

Dr. Carlos Meriles, acknowledged earlier by Dr. Ehlers, is Assistant Professor of Physics at the City College of New York, and a current NSF Career Grant awardee. Dr. Meriles, thank you for being here.

And Dr. Jeff Welser is on assignment from IBM Corporation, to serve as Director of the semiconductor industry's Nanoelectronics Research Initiative. Dr. Welser, thank you.

The—we have chatted briefly before the hearing, as you know. We have five minutes to speak. Dr. Ehlers has a button. At the end of five minutes, he or I will push it. The person exceeding that time will disappear. And actually, we are only kidding, especially with this panel. If you go a couple seconds over, that is all right.

And we look forward to both excellent testimony, and then, a nice give and take in the questioning. And we will start with Dr. Wise. Dr. Wise, thank you.

STATEMENT OF DR. PHYLLIS M. WISE, PROVOST, UNIVERSITY OF WASHINGTON, SEATTLE

Dr. WISE. Mr. Chairman, Congressman Ehlers, it is an honor to be here today. As you have introduced me already, I am Phyllis Wise, from the University of Washington.

My very first research grant came from the NSF in 1975, and I really want to thank Congress for supporting my research career throughout, and I want to thank you for giving me the opportunity to give you a little bit of a University of Washington perspective.

Last year, UW researchers performed sponsored research for $990 million, of which $94 million came from the NSF. It funded 587 principal and co-investigators, and literally hundreds of postdoctoral fellows, graduate students, undergrads, and high school students, who worked with our researchers.

The mission of the National Science Foundation, that is to discover and disseminate knowledge, has generated a process of determining, by merit, the best kind of fundamental research that deserves funding. It is different from asking a very specific question, focused on a very defined problem. And as such, it is truly unique.

When the human mind is driven, through curiosity, to inquire about how something works and why it works that way, we really are in the heart of innovation. For example, a couple of very passionate UW investigators looked into the biology of insect development, and discovered the hormonal regulation of that development. This research led to the control of crop pests, and also the control of mosquito populations that are threatening us with malaria.

And who would have thought that understanding insect locomotion would affect the U.S. space missions? But in fact, the control of the circuit of six legs on walking stick insects is a form of distributed computer control that is now used in six legged robots that are in the Mars mission. No other nation has had the courage to put confidence in human intellect to the degree that the NSF has. And no other country in the world has really benefited from that kind of success from this kind of research.

Perhaps about 50 percent of the United States' economy growth since World War II has come from this scientific enterprise, and your commitment to increasing that investment is really, truly critical.

As a result of prior Congressional investments in the NSF and other federal science, we are now at an age of fascinating enabling technologies that really blur the boundaries between social, physical sciences, health sciences, life sciences, engineering, and mathematics. And it really begins to recombine in very new and exciting ways, so that we are not any longer just describing. We are truly being able to predict, we are truly being able to analyze in ways that we have never done before.

The Committee is looking into interdisciplinary work, the engagement of the enterprise in STEM education, the nature of industry relationships, and the opportunities for junior researchers. And I have given considerable detail in the written testimony that

I have given you. So what I would like to do in just the short amount of time I have today is to really concentrate on two areas. First is graduate students and undergrads. As you have mentioned, they are critically important. And also, in the infrastructure that really serves as the underpinning for all of this.

So, it is really impossible to talk about science and research without talking about graduate students, undergraduates, and the high school students who actually get their first experience in science through funded research. They do not make policy. They do not write the grants. But they are truly the engine that allows the research to be funded and successful. And recruitment of our young assistant professors, as you will hear, is really dependent upon our ability to have graduate students and undergraduates work in their laboratories. As is the one year pilot funding program, which is in the draft legislation, these new faculty members depend upon those kinds of student help.

The most common model of research assistance really doesn't work today in the interdisciplinary kind of research that we are really trying to do. The IGERT programs, which fund graduate students and postdocs, in a transdisciplinary, multi-disciplinary, interdisciplinary way, is so key to the new way that we are doing science, and we hope that this program will get, in fact, increase attention, and that renewable IGERTs really become part of the NSF programs.

And just a few words about infrastructure, it is really appropriate to review the investment in facilities and instrumentation, as you, the Chairman, recommend in H.R. 1067. I believe that major research instrumentation programs should increase at a much greater rate than it has in the past, because nowadays, tools are the science, and that is really true in almost every scientific discipline. Manipulation of large, complex datasets is revolutionizing the way we turn data into information, information into knowledge, and knowledge into real understanding. And for that, we really, really need the kind of large instrumentation that is part of the program that is funded by the NSF. And it is only appropriate that the NSF sponsor and adjudicate its resources, but also, that there is a sufficient pool of funds to reflect the importance that instrumentation plays in allowing students to be able to partake of research.

The scope of UW research, in particular, involves significantly in the major research equipment and facilities construction, that is supported by the Foundation. And we watch, with great anticipation and hope, the Oceans Observatory Initiative, as it winds its way through. The Undersea Laboratory that will be constructed in our front yard, in the Juan de Fuca Tectonic Plate in the Northeast Pacific, is really one of the kinds of examples of how NSF is going to enable us to see and observe, in real time, what is going on in our ocean floors, to understand more about earthquakes, to understand more about the climate changes that we are undergoing, the populations differences and changes and migration of many of the animals that live in the ocean.

So, all of the aspects of the NSF are truly valuable. I am sure you will hear more about this from all of our other witnesses.

Thank you very much for this opportunity.

[The prepared statement of Dr. Wise follows:]

PREPARED STATEMENT OF PHYLLIS M. WISE

Mr. Chairman and Members of the Subcommittee:

My name is Phyllis Wise. I am Provost and Vice President for Academic Affairs at the University of Washington and Professor of Physiology and Biophysics, Biology, and Obstetrics and Gynecology. My first research grant was from the National Science Foundation (NSF) in 1975. I'd like to thank the Congress for that support as it launched a long career of research in which I still engage. I would also like to thank you for the opportunity to appear before you today to provide a perspective from the University of Washington regarding the National Science Foundation (NSF), its important work and the prospects of making it even stronger in accomplishing its mission of knowledge generation and dissemination through fundamental research.

The reauthorization of the National Science Foundation (NSF) in 2007 presents an unprecedented opportunity to renew and reinvigorate the national commitment to excellence. As a result of prior Congressional investments in the NSF and other federal science, we are now in an age of fantastic enabling technologies that blur the boundaries of disciplines and change the very nature of scientific inquiry from a descriptive endeavor to a predictive one.

This is a moment in the history of science when we have the tools that revolutionize how we collect, analyze, order, organize and retrieve data. We are in a time when imaging, simulation and robotics are part of the regular curriculum for the training of health professionals; where oceanographers consort with computer engineers and telecommunications experts to peer at the bottom of the ocean in order to learn about life in extreme environments so others can make predictions about the life in outer space; and where the living brain's operations can be observed, where emotion and even learning inside the brain can be detected and analyzed. It is wise that the Congress, in particular this committee and subcommittee, has elected to enhance an agenda that would spur discovery and encourage young Americans to get involved in these scientific frontiers.

These new technologies present challenges to existing structures and customs and it is the role of Universities and their partners in the Federal Government like the NSF to be thoughtful stewards of the human resources that drive this enterprise. Thirty-five percent of the money NSF spends is for human capital, that rare commodity that generates new ideas, tests them, analyzes them and brings them to a stage of invention that can be transferred to the classroom as knowledge and to the commercial sector for development.

Universities have a duty to educate and prepare the students who come to their doors in a way that makes them responsible scientists and engineers. Those who are not destined for these careers also need to be scientifically literate. But our joint duty doesn't start or end with the students at our doors. Our nation needs to claim every resource, every talented student without regard to family income or social status or cultural background. Every kid needs a fair chance to become excited by the prospect of science, or engineering or mathematics as a career. Scientific and mathematics literacy must become a basic tenant of his/her education. No one questions whether a student must learn to read. The 21st Century literacy imperative must include mathematical and scientific literacy. The NSF and all of higher education need to embrace this goal and help to inform and guide the K–12 sector through teacher training and through continued research in the science of learning.

The NSF is unique among public agencies in having a mission to generate and value what is innovative. The process that has evolved at NSF for determining what constitutes a meritorious avenue of pursuit has been extraordinarily effective. Asking creative people to solve a defined problem is not the path to discovery. It may be the road to finding a creative solution to a specific problem but that is not innovation, that is problem solving. When a new way to ask questions or seek answers or combine materials or invent materials is pursued; when the human mind is engaged through curiosity to inquire about how something works or why it works the way it does, that is innovation. No other nation has had the courage to take that risk and put its confidence in human intellect to such a degree and no other has had the success of the U.S. in harvesting the fruit of that courageous confidence.

With more than 50 years of U.S. investment, the payoff to the Nation has come in the form of new knowledge resulting in new products and processes that have, in turn, spawned a remarkable economic impact and an impact on health. Other nations are trying to emulate this model. The reward the U.S. has had for this investment has been priceless in terms of economic development, improvements in human

welfare and abundance of inquisitive minds that continue to ask important questions. Clearly, there are important national needs like those articulated in the American Competitiveness Initiative (ACI) and they need to be honored in defining broad areas of inquiry. The NSF process for approaching those areas should not change. The merit based method of determining successful proposals is the most cost effective and most productive. We cannot anticipate what will be discovered or force a discovery. Science is at once methodical and unpredictable.

At our own institution for example, inquiry by UW scientists Jim Truman and Lynn Riddiford, who were passionately interested in understanding the biology of insect development, led to significant understanding of hormonal control of development. This research area has, in turn, had significant impact in the control of crop pests as well as mosquito populations in regions with raging malaria. The research was never intended to solve those problems. Rather, it was focused on trying to understand the most basic aspects of how animals control the sequence of events that surround development. And, who would have thought that the control of insect locomotion would affect the U.S. space program? Indeed, the control circuit of the six legs of walking stick insects is a form of distributed computing control that has since been used as a model for how six wheeled robots move. The Mars Rover is one of the best examples of systems inspired by insect neural systems. Similar concepts are emerging today on robots with compliant legs and wings—Professors Thomas Daniel at the UW along with Michael Dickinson at Caltech and M.A.R. Full at UC–Berkeley—are showing how studies of animal movement are inspiring new devices and designs. Biologists working in this area were not striving to create robots. Rather they were trying to understand the basic rules of nature.

Or, who would have thought that studies of adaptation, change, and the genetic basis of phenotypic variation would be used to solve complex mathematical problems? NSF has had a long and rich history of funding basic research in evolution and principles of this discipline have become embroiled in every aspect of our practical lives, from how we solve complex computational problems using genetic and evolution algorithms to how we use computers to develop better devices and machines.

Now, when our economic future is at stake, is the time to pick up on the wisdom of the National Academies of Science (NAS) study (*Rising Above the Gathering Storm*) and amp up the investment in our most precious raw material, human minds. The expressed intentions of this committee and its efforts to set new levels of funding for the National Science Foundation are critical to our nation's future.

In addition to responding to the questions the Chairman has raised regarding young investigators; our university relationships with industry; the balance between interdisciplinary and disciplinary research; and the process for integrating undergraduates in STEM education, I will offer some thoughts on graduate students and on ways to strengthen the noble partnership between the NSF and the Nation's research universities.

1.) How do new investigators at your university fare in getting NSF research grants? Does the university administration have any policies or mechanisms in place to assist your young faculty in securing funding or are those efforts strictly department-driven? Do you have any suggestions as to what NSF may do differently to improve funding success rates for new investigators?

Ensuring that our young new faculty members have a fair chance to succeed is of paramount importance to the University of Washington. As we compete with other top universities for the 'best and the brightest' young faculty, we make sizable investments in the form of recruitment packages. Start-up packages are provided with the understanding that setting up a new research program is expensive, and that such funds are necessary to give young faculty a chance at competing nationally for research dollars. It is not unusual for these packages to be several hundreds of thousands of dollars. But these funds are seldom enough to actually fund a research effort for the two or three years it takes to build a laboratory (if needed) and establish a productive research program. As a Tier 1 university, there is strong expectation that our new faculty develop productive, externally funded research programs within the first four to five years (promotion and tenure decisions are generally made in their fifth or sixth year). If external funding is not obtained in that time frame, promotion may be denied, and the faculty member may be forced to leave the UW. Not only is this a significant personal and career setback for the talented individual, but it represents a sizable loss of our investment.

Thus, it is imperative that we do everything that we can to help young investigators succeed. In addition to start-up packages, we direct approximately $2 million per year of royalty income (from UW inventions and other intellectual property) into an internal competitive grants program called the 'Royalty Research Fund.' Al-

though not exclusively for junior faculty, it is heavily focused in that direction. Even with this program, only 25 percent of the applications we receive from junior faculty can be funded. But these funds provide a critical means for young faculty to gain experience in writing proposals, and also to obtain preliminary data that is often necessary to compete successfully for federal funding, including through the NSF.

How well do our junior faculty compete at NSF? Overall, faculty at the University of Washington do somewhat better than the national average in competing for NSF grants, but it is getting harder. For example, in FY2000, our faculty submitted 353 applications to NSF, and 154 were funded, for a success rate of 44 percent (the NSF average success rate was 33 percent). In 2006, our faculty submitted 460 grants (23 percent more than in 2000), and 158 were funded, for a success rate of 34 percent (the NSF average success rate in 2006 was 25 percent). Unfortunately, it is difficult to identify how many of these applications come from new Assistant Professors, and thus hard to say- with data—how well our new faculty do, compared to more 'seasoned' investigators. However, there is little doubt that, as 'paylines drop,' junior faculty are disproportionately affected. As competition increases, the expectation of grant reviewers for a proven track record (e.g., publications) and substantial amounts of preliminary data continues to rise at a dramatic rate. This puts new investigators at a decided disadvantage in the competition. This is why it is essential that federal agencies establish funding mechanisms that are specifically directed at new investigators. In recognition of this problem, National Institutes of Health (NIH) Director Elias Zerhouni recently announced a new "NIH Director's New Innovator Award" to support exceptionally creative new investigators who propose highly innovative approaches that have the potential to produce an unusually high impact." The NSF is an active sponsor of the Presidential Early Career Award for Scientists and Engineers (PECASE), considered to be the highest national honor for investigators in the early stages of promising research careers. The University of Washington is proud that we have received three of these PECASE awards just in the past two years. This program recognizes the 'cream of the crop' of outstanding young research scientists across the country, and is an important source of support for these chosen few. But it does not solve the problem of how we maintain a vibrant cohort of young faculty that represent the future of academic research, but who require research funding in their earlier years to simply survive in an increasingly competitive environment.

I encourage NSF to take additional bold steps to ensure that promising junior faculty have the opportunity to succeed. I was pleased to learn that the Committee is considering a new NSF program that addresses this issue, entitled "Small Grants for Exploratory Research"—a pilot program in which excellent proposals from new investigators that are not funded by the merit review committee can be funded for one year, at the discretion of the program officer. This is an innovative approach to addressing the challenge of new investigator funding. This approach does not circumvent the peer review process, yet will allow promising new investigators short-term funding to collect critical proof of principle data that are increasingly required to compete successfully for a full NSF award. Providing NSF staff with the authority and resources to decide which new investigators do and do not get such pilot funding is a reasonable approach for streamlining this process. Of course, a key issue will be, "how far the money can go." Innovative new programs such as these are going to be increasingly important to ensure that we do not lose an entire generation of young faculty in academia. Increased support for the federal research agenda, especially NSF, is essential if our junior faculty are to establish successful research careers in academia.

2.) Please describe your university's relationship with local industries. How does the university administration help connect your faculty with local business entrepreneurs and leaders? Do you keep track of industry cost-share on NSF grants? Do you have any suggestions as to what NSF may do differently to facilitate university/industry partnerships at major research universities?

The Pacific Northwest has a culture of its own. Our traditional industries like aerospace, headlined by Boeing, and resource based industries like timber and logging no longer dominate our economy. They are complemented by a dazzling array of innovative high tech industries like Microsoft and Nintendo, iconoclastic retailers like Costco, Nordstrom and REI and unusual prototypes businesses like Starbucks and Amazon. There is an entrepreneurial spirit that may be attributable to the independence of the original settlers and a premium on thinking outside the box. Perhaps more unique but maybe more predictable, there is also a culture of collaboration which helps us to work across sectors. Businesses and the academy have always been closely tied in the Northwest and even regional governments collaborate. The UW medical school is the medical school for five states (Washington, Wyoming,

Alaska, Montana and Idaho), who all got together almost four decades ago and decided to cooperate instead of compete. So they developed one top ranked Medical School to serve everyone.

The industry leaders of the region have a huge investment in the health of the universities. The universities, colleges and community colleges provide the next generation of thinkers, designers, and workers for these firms and provide an attractive enticement to employees they are trying to recruit. Reciprocally, the University sees this lively entrepreneurial environment as a recruitment tool for top faculty and students. There are many forums for university/industry engagement including participation of industry leaders on advisory boards across campus. Local business people also sit on visiting committees in almost all of the colleges and schools. There are numerous technology showcases such as the Northwest Entrepreneur Network as well as the Washington Biotechnology and Biomedical Association (WBBA) and the Washington Technology Center, which both host showcases to connect university researchers with local business leaders. The UW Office of Technology Transfer is active in the local business community and sponsors a program called LaunchPad where experts recruited from the business community mentor faculty on start up opportunities. The Seattle World Trade Center also serves as a facilitator for introductions on a case by case basis. The UW Office of Research has also set up an industry portal for easier access to its treasury of information.

The Board of Regents of the UW is appointed by the Governor and has always included major industry and community leaders in its number (e.g., we have had members of the Gates family on our board long before Bill Gates was in high school). Our relationship with local industries is healthy because we are viewed as part of the community. More than 200 companies have been spawned by the UW and many of those stayed right in the area. Our former students and some current faculty are researchers at Microsoft and vice versa. Our President, Mark Emmert, and his administration work closely with community leaders through a number of different networks, the Puget Sound Partnership, the Washington Technology Alliance, the Washington Biomedical and Biotech Alliance and others.

We are fortunate to be in a community that cares. Our strongest connection with industry is through our students who join local work forces and continue to have ties to the campus. The UW administration works on a policy level to make connections with industry. The actual affiliations on the project level are conducted through faculty and an informal communication network. Our faculty are extremely entrepreneurial themselves and we have more than 1071 agreements for research with industry. Although we do not keep track of industry cost sharing on federal grants on a regular basis, we do track contributions when they are articulated as part of a grant proposal, as in the Engineering Research Center or Science Technology Center grants and others.

We feel the most effective partnership with industry and NSF is exemplified by our Engineering Research Center (ERC). In this case there is support from both industry and Federal Government and a sharing of the goals and objectives of the program. Issues are negotiated at the outset and there is a lively exchange and participation with all sectors. Through this type of mechanism, we are able to overcome the difficulties inherent in multi partner arrangements, namely, rights to information and data, control of direction of research and potential conflicts of interest which could interfere with reporting of research results. The ERC model is tried and true.

3.) What is the appropriate balance between funding for interdisciplinary and disciplinary research? What models or frameworks for interdisciplinary research seem to work best at your university? Is NSF doing a sufficient job of publicizing opportunities for funding of interdisciplinary proposals to your faculty?

In keeping with our culture of collaboration, the UW has a long history of interdisciplinary research. We like to think we are the great university we are today because our faculties have always talked within the UW and across the boundaries of disciplines. This may be due to the splendid isolation of our geography or our often soggy climate, but our various faculties have always talked a lot to each other rather than exclusively to their disciplinary counterparts at other places. There is a t-shirt about Seattle that summarizes the phenomena. "Seattle: Cool, Caffeinated and Connected."

This expectation of collaboration and synergy has resulted in more internal receptivity to unusual organizational arrangements and more flexible structures for creating new interdisciplinary departments and relationships. Typically, the actual projects are developed from the faculty rather than in response to external stimuli though we are always attuned to calls for proposals from sponsors, and the Provost's office often brings folks together to explore concepts. The UW Department of Bio-

engineering for example, is the oldest one in the country by a decade. We have just formed a Department of Global Health one of the first in the Nation, which is a joint department between two Schools (Medicine and Public Health) and involves jointly appointed faculty from numerous other departments across the University. There are not always federal funding counterparts to our new hybrid departments, so the challenge becomes one of characterizing the work in terms of the advances that will be made in each of the several disciplines. We are aware of the Congressional and NSF efforts to encourage funding for interdisciplinary work and we applaud it.

We also feel the federal experiments with multi agency joint projects are very important. For example, the University of Washington is home to the Pacific Northwest Center for Human Health and Oceans Sciences and along with three others is funded jointly with NSF and NIEHS (National Institute for Environmental Health and Safety) dollars. This is the first time these two agencies have joined forces and the Centers are tackling the new area of oceans and human health. One sample of the work is looking at gene environment interactions where both ocean scientists and human health researchers look at genetic diversity and environmental exposures or conditions to define response and mechanisms. The National Academies report entitled *Facilitating Interdisciplinary Research, 2005* (*http://www.nap.edu/catalog.php?record_id=11153*) gives a good roadmap for future interactions. Our project works well because both agencies have a commitment to basic science and that is proving to be key.

Putting transdisciplinary teams together to do BIG science is rewarding but the challenges administratively are formidable. Our embattled researchers suggest that the two very different grant mechanisms and cultural approaches should be recognized and more flexible administrative structures be improvised. The process for applying for projects which cross more than one agency are very cumbersome and discouraging. It would help to have a uniform process in the Federal Government so if we must make duplicate proposals to several agencies for the same project, that at least we could use the same forms and some shared expectations.

As for the balance between interdisciplinary work and disciplinary research, it is a healthy tension. There is no question that the work of individuals advancing their unique disciplines forms the pillars of any interdisciplinary structure. We cannot forsake the individual investigator grant. It is also a way for young investigators to prove their value to an interdisciplinary team. Interdisciplinary work moves many disciplines forward and affords a new look at problems; a look with many different types of tools or skill sets but it will always be limited by the quality of the individuals represented. Because of the advent of new tools, like advanced computing, the borders between a lot of disciplines are disappearing or reconfiguring. This is an important time to use the new enabling technologies to explore and it probably warrants an explosion of interdisciplinary work. But each generation of investigators needs an opportunity to make a contribution at the disciplinary level and these grants must remain the core of the portfolio.

A possible mechanism to support junior researchers and create interdisciplinary ties would be to provide funds to supplement existing interdisciplinary projects for the purpose of adding a junior investigator, analogous to the way the NSF "Research Experience of Undergraduate" program funds opportunities for undergraduate research to existing projects.

4.) Please describe the process by which undergraduate science, technology, engineering and mathematics (STEM) curricula at your university are reviewed and updated as necessary in response to shifting paradigms in these fields. What role does NSF play in this process? Do you have any suggestions as to what NSF may do differently to assist universities in maintaining world class undergraduate STEM education?

At the UW we have a commitment at the highest level to ensuring students who attend this research university reap the benefit of the research environment by participating in the research experience. The UW reports undergraduate engagement in research with faculty as one of our institutional accountability measures to our state legislature. This past academic year, we counted more than 4,000 student-quarters of intensive research (10 or more hours a week). Each Department at the University determines how it will incorporate experiential learning into its curriculum. In addition, we engage in a wide range of outreach programs to teachers and students in the community. Through funding from the Carnegie Corporation under their "Teachers for a New Era" initiative, science faculty in the College of Arts and Sciences are working with colleagues in the College of Education and local schools to develop a new Integrated Science undergraduate degree program that will be especially suitable for future secondary science teachers. Our existing science de-

gree programs are too specialized for many future teachers, and in turn many teachers do not have a sufficient science background. This program will fill the gap.

Regarding the incorporation of new disciplinary paradigms in core curricula, all departments are reviewed every 10 years, more often if the review raises important issues. At the time of review, both the undergraduate and graduate curricula are examined by both internal faculty and outside experts in the field. While this is the primary formal process for curricula review, most departments or programs review their curricula on a more frequent basis. Indeed, whenever a faculty member retires, or a new faculty member is hired, an opportunity is created to rethink how departmental or program curricular offerings should change to suit changes in the field. For most large departments, this happens on an almost yearly basis. NSF does not play a role in this process. Also, the fact that our faculties are actively engaged in research and teaching facilitates the transfer of research related discovery to the classroom independent of the formal structures for establishing curriculum.

The role and responsibility of NSF in STEM education and program evaluation is not clear. I would associate myself with the Association of American Universities (AAU) comments on the NSF strategic plan: *". . .an important area for improvement in the plan is how NSF defines its role in this area. AAU would encourage NSF to define more precisely its specific role and responsibilities in the training and education of our nation's future scientists and engineers at all education levels. This includes clarifying how its role is both unique and complementary to that of other federal agencies such as the U.S. Department of Education. We feel that this plan provides an opportunity for the NSF to clearly define its role in education and that the draft plan as written does not take full advantage of that opportunity."*

One way for the NSF to ensure that undergraduate STEM curricula include leading edge research is to continue to support programs that fund this kind of work. For example, the NSF course, "Curriculum and Laboratory Improvement" (CCLI) offers funding to faculty who wish to develop innovative curriculum in STEM. One such grant at UW is to Professor Mari Ostendorf to improve a teaching lab for systems courses in Electrical Engineering. The NSF "Science, Technology Engineering and Mathematics Talent Expansion Program" (STEP) provides funding to faculty and staff who wish to increase the number of undergraduate majors receiving STEM degrees. It is a program that promotes student professional development and curricular improvement by providing financial resources to institutions. Our college of Engineering has a collaborative STEP grant with Washington State University to work with four Washington state community colleges (Seattle Central, Highline, Columbia Basin and Yakima Valley) to increase the number of students transferring to the four year institutions to receive engineering degrees. The NSF grants process encourages, and often requires, a focus on educational mission. However, it would be especially useful if NSF were to provide grants to individual faculty that would provide them release time to update and improve undergraduate courses. Support for graduate Teaching Assistants, which are often paid at lower levels than graduate assistants, would also help to improve undergraduate education, both directly in terms of the courses they Teaching Assist (TA) for, and indirectly by providing future researchers teaching experience. Grants for updating and improving undergraduate laboratories would also be extremely helpful, as this is becoming increasingly expensive.

On a related STEM Ed issue, we do feel that the NSF Math and Science Partnerships (MSP) program is best positioned in the NSF where scientists feel welcome and in charge of the activity; where the science or math expert dominates the process. We have observed that the passion to pursue the disciplines is better transferred from those professing it. We also feel it is ironic that at a time when the administration is advocating increases in STEM education, the budget proposals for the NSF Education and Human Resources (EHR) budget have lagged behind the rest of the Foundation.

GRADUATE STUDENTS

I am remiss that my testimony has advanced this far with the peculiar absence of two key terms: graduate students and post-doctoral fellows. To talk about research and leave out the energy that fuels the laboratories and teaching of science and engineering in the United States is a glaring error and I will remedy it. Neither group makes policy or is the Principal Investigator (PI) on grants but the success of any research policy or the performance of any laboratory is dependent on these warriors in the battle of discovery. The frustration of new faculty in their quest for grants is amplified as they have to find funds to support students. Recruitment and retention of faculty is highly linked to the support of graduate students. Nearly all of our new assistant professors say that the single most important issue they face is recruiting excellent graduate students. The most common model of support for

graduate students, as Research Assistants on research grants, does not support enriching rotations and interdisciplinary research. We need to find ways to encourage that through auxiliary funding streams. Further, the NSF policy of five year non renewable graduate training grants moves money away from potential successful formulations of mentorship and interdisciplinary work. Long-term support to broad inclusive graduate programs is needed. The programs that do exist, such as the IGERT (Interdisciplinary Graduate Education Research and Training) program, should be expanded.

THE PARTNERSHIP

The University of Washington shares the fundamental research mission and education mission of the NSF. In FY 2006, UW researchers performed $989.70 million in sponsored research, most of it funded by the Federal Government. Of the federal total, NSF is the second largest federal contributor to the UW research enterprise and contributes approximately 10 percent to the total amount, and every directorate is represented. In every discipline we are partnered with the Federal Government. In FY 2006, UW received 587 grant awards from the NSF, totaling approximately $94 million dollars. These awards were directed by 378 different UW faculty (Principal Investigators) and included an additional 432 as co-investigators, thus providing partial support for over 800 UW faculty researchers. In addition, NSF grants support hundreds of post doctoral fellows, graduate students, and undergraduate student researchers.

Because the Foundation and the University have mutual missions they have formed a partnership that serves the Nation in important ways. We are appreciative of the work of this committee in particular in advancing the recommendations of the National Academies report *"Rising Above the Gathering Storm."* The report raises national issues that must be addressed. It will require the achievement of delicate balances in order to accomplish our shared goals. These balances represent tensions on a variety of levels; between large multi-disciplinary grants and grants to individual researchers; between seasoned and meritorious researchers and their junior brethren; between the forces that draw math, science and engineering graduates away from teaching leaving a disproportionate number of our K–12 teachers of math and science without strong disciplinary training in these critical fields. Balances between the involvement of industry in setting the research agenda and the need for unfettered exploration also need to be addressed. There are balances on the procedural level as well. These are expressed in the need of NSF program officers to stretch dollars, sometimes forcing funding decisions down to the campus level and sometimes creating a dynamic which impairs the partnership and the purposes of peer review.

INFRASTRUCTURE

I am encouraged by the Chairman's intention to increase the investment in infrastructure. It is appropriate to review the investment in facilities and instrumentation as the Chairman recommends in H.R. 1067. I believe the "Major Research Instrumentation" (MRI) program should have an accelerated rate of increase, beyond the administration's contemplated increase in the size and number of individual awards. This is an age where the tools for science have become the science in almost every discipline. The manipulation of large complex databases is revolutionizing every field and the scramble for funds to pay for the development of the next generation of instrumentation for research and research training is enormous. It is appropriate not only that NSF sponsor and adjudicate the resources but also that there be a sufficient pool of funds to reflect the importance of instrumentation to success in science. The NSF initiative for "Cyber-enabled Discovery and Innovation" (CDI) is also one of the cross cutting programs that is essential in this environment.

The scope and breadth of the University of Washington research portfolio means we are involved significantly in many of the Major Research Equipment and Facilities Constructions (MREFC) efforts supported by the Foundation. In fact, we watch expectantly as the Ocean Observation Initiative moves through the MREFC python. The undersea laboratory component will be constructed out our front door, on the Juan de Fuca tectonic plate in the North East Pacific, and we have made considerable investments as an institution in the development of this initiative. The science that is anticipated is sublime. It will involve oceanographers of course, but also marine biologists, seismologists, geologists, vulcanologists, fish scientists, astrobiologists, civil, mechanical and computer engineers, robotics specialists and computer scientists of all stripes and more. Real data in real time streaming from the bottom of the sea onto the world wide web to fuel hundreds of scientific minds and inspire generations of curious students; the scale of this project is hard to fathom, but the NSF and a phalanx of scientists from around the country will get it

done with the help of Congress. Exploring the bottom of the sea is an extraordinary frontier for science and for future scientists who will be inspired by it at an early age.

Money is the issue. There are many extraordinary projects in the MREFC queue. Congress needs to stay committed to advancing the program despite the demands to spend money elsewhere. These are investments in the future and should not be viewed as simple expenditures or short-term fixes.

POLICY AND PROCEDURAL ISSUES

There are some policy and procedural matters that I would like to raise with regard to some existing programs, particularly those that focus on building infrastructure, broaden participation, improve educational opportunities or support the development of multi-disciplinary centers or multi institutional partnerships. In particular, we are concerned about the limitation on the number of proposals that may be submitted to over thirty of such NSF programs. When large institutions with strength in an area targeted by the program are allotted the same number of proposals as small institutions, or institutions without strength in the program, it is inevitable that the program is not receiving all of the top proposals. An example of the problem is the IGERT (Interdisciplinary Graduate Education Research and Training) program. This is an excellent program, fostering novel interdisciplinary training programs and the development of new curricula to address pressing national problems. However, institutions such as the UW that have a strong track record in developing such programs are allowed the same number of submissions as other institutions that do not have the same capabilities. Currently, four proposals are allowed, which are reviewed at various Directorates and the best are chosen for submission of full proposals. However, the institutional limit for full proposals is only two, creating the difficult situation that at the UW, when more than two are picked for full proposals, the institution must withdraw a pre-proposal that was judged by peers to be highly meritorious. By this process, NSF is eliminating some of the strongest possible proposals. This is especially true if the pre-proposals that were selected are in different areas of research (e.g., different directorates).

In addition, at larger institutions priorities are normally set based on impact, which often scales with the numbers of faculty and/or the number of students. Therefore, traditionally smaller areas tend to not be as well represented as areas that are larger. An example is Geosciences, which at most institutions is one of these smaller areas. However, it is extremely important for emerging environmental problems. In general, for programs such as the IGERT program, these disciplines tend to not make the final cut of the top four which we would send as pre-proposals because of the scale. We recommend that NSF should limit the number of programs for which small (1–2) institutional limits are imposed to those that require especially onerous review, such as centers or other programs that require site visits. In cases in which limits are imposed on pre-proposals, any pre-proposal chosen by peer review should be allowed to be submitted as a full proposal. If it is deemed important to impose total programmatic limits, then larger institutions should have a scaled limit, according to either total faculty size or NSF funding.

One other procedural matter presents public institutions with a particular problem. The issue of institutional matching funds was addressed in recent years as schools worked with the NSF Director and the National Science Board (NSB) and even the Congress to stop the escalating bidding wars that went on in some NSF programs. Program directors attempting to husband their scarce resources would launch rivalries among highly ranked proposers to provide institutional matching funds to make the proposal more attractive to the officer. The NSF director issued directions to stop the practice, and the NSB stated that no matching was required. The practice has re-emerged as the language stating that no match was required is being interpreted as not required but voluntary. State supported institutions cannot use public funds to support federal projects. We would like to see the practice of pitting PIs against their institution stopped.

Despite these difficulties, the NSF-University partnership is extraordinary. The Foundation has always been a model of administrative efficiency and manages an extraordinary portfolio of some 350 programs. Nearly half of the NSF workforce consists of scientists and engineers, all leaders in their fields who are among the 1,300 involved in the processing and management of research awards. Adequate funding for operations and award management, particularly in the information technology field is critical to the agency functioning as efficiently as possible. While the overall research budget appears to be on an upward growth path, funding for operating expenses has remained essentially flat. As mentioned earlier, we have been submitting a lot more proposals and this is probably replicated by other like institutions. The collaborations with other schools and across agencies require a lot more human in-

volvement at the Foundation level. NSF, like the Universities it serves, depends on top quality staff and that means favorable employment environments. We support increases for NSF infrastructure.

In closing, I would like to observe that science has moved from behind the scenes to the center of the stage in terms of helping our nation to stay competitive. We need to harness the human potential in every American kid and facilitate the efforts of those who do choose careers in research by streamlining the processes and making them more accessible. This is a huge task at a time when the Nation's coffers are depleted but given American ingenuity, the National Science Foundation, the Nation's research universities and some help from Congress, we can get it done. I appreciate the opportunity to present my views and I offer my help in any way to assist the Committee.

BIOGRAPHY FOR PHYLLIS M. WISE

Phyllis M. Wise became Provost and Vice President for Academic Affairs at the University of Washington, on August 1, 2005. As the University's chief academic and budgetary officer, the Provost and Vice President for Academic Affairs provides leadership in educational and curriculum development, formulation and allocation of budget and space, long-range strategic planning, and management of the University's research programs. She serves as deputy to the President and provides advice and assistance to him and to the Deans and the faculty in these matters.

Wise, who is a Professor of Physiology and Biophysics, Biology, and Obstetrics and Gynecology at the University of Washington, previously served as Dean of the College of Biological Sciences at the University of California at Davis, from 2002 to 2005. Prior to that, she was Professor and Chair of the Department of Physiology at the University of Kentucky in Lexington from 1993 to 2002. Wise was a faculty member at the University of Maryland, Baltimore, from 1976 to 1993, promoting through the ranks to Full Professor of Physiology in 1987.

She holds a Bachelor's degree (1967) from Swarthmore College in biology and a doctorate (1972) degree in zoology from the University of Michigan.

Provost Wise continues an active research program in issues concerning women's health and gender-based biology. She has been particularly interested in whether hormones influence brains of women and men during development, during adulthood and during aging. She has been involved in the discussion of whether males and females have different strategies in learning and memory and whether this may make them more suited for some careers as opposed to others. She has been continuously funded by the NIH for over 25 years and has received two MERIT Awards, which provide funding for innovative research over a 10-year period of time.

She has served on a number of scientific advisory committees, including NIH study sections, NIA Advisory Council, the NIH Advisory Committee on Research on Women's Health, the advisory board for the Oregon Regional Primate Center, the advisory board of the University of Michigan Nathan Shock Center for Biological Aging, the Kronos Research Foundation Board of Directors, the Buck Institute Board of Directors the Allen Brain Institute and the Bullitt Foundation.

Wise was featured in *Parade Magazine* cover story on "The Quiet Heroes" engaged in lifesaving research. She has received many awards, and is particularly proud of those that have acknowledged her lifelong dedication to mentoring students and junior investigators, particularly women. She received the Excellence in Science from the Federation of American Societies for Experimental Biology in 2002, and the Women in Endocrinology Mentor Award in 2003.

Chairman BAIRD. Thank you, Dr. Wise. Dr. Hunt.

STATEMENT OF DR. CATHERINE T. HUNT, PRESIDENT, AMERICAN CHEMICAL SOCIETY

Dr. HUNT. Chairman Baird, Ranking Member Ehlers, and distinguished Members of the Subcommittee. Good afternoon. As President of the American Chemical Society, it is my great pleasure to be here on behalf of our 160,000 members.

As you are keenly aware, the United States faces unprecedented challenges with economic and technological leadership from global competitors who are investing heavily in research and education.

Today, the NSF provides about one fifth of all federal funding in support of basic research in America's colleges and universities.

Chairman BAIRD. Dr. Hunt, is your mike on? Or maybe swing it a little bit. That sounds——

Dr. HUNT. How about now?

Chairman BAIRD. Yeah, that is much better. Thank you.

Dr. HUNT. Okay. So, maybe I will just stretch back just a bit.

On behalf of our more than 160,000 members, I am pleased to be here today.

As you are keenly aware, the United States faces unprecedented challenges to its economic and technological leadership from global competitors who are heavily investing in education and research. Today, the NSF provides about one fifth of all federal funding in support of basic research at colleges and universities in America. The Foundation also plays an essential role in addressing challenges in the area of STEM education.

The NSF, likewise, has been given the challenging mission of promoting science on a broad basis, and bridging the gulf between scientific advances and public understanding. I also have submitted a written statement for the record, and welcome the chance to offer a few observations on how NSF can achieve its goals over the next five years.

I would first like to address the question of how NSF might take a more active role in cultivating the new generations of scientific innovators. Young minds with fresh ideas are essential to advancing our understanding of science. So, it is of paramount importance that we give young investigators ample opportunities to compete for the funding they need, to establish research programs in academe and elsewhere.

We applaud the Committee for advancing legislation recently that would strengthen the NSF Career Program by linking its funding to the overall science budget, the NSF budget, so that as NSF grows, so will its support of young investigators. Unfortunately, as NSF's budget has remained flat over the last several years, we have seen a marked increase in competition between established researchers and young investigators.

One reason our members have strongly supported the American Competitiveness Initiative and other efforts to bolster our innovative capacity is that by increasing the size of the grant pool, we will avoid, if you will pardon the analogy, robbing Peter to pay Paul. In reality, we need to support both Peter and Paul if we intend to keep producing the tremendous array of innovations that keep our country competitive.

I am delighted that the budget resolution on the House floor today would provide a significant boost to our investments in research and education, and thanks to the many Members of the Committee that have worked with the House leadership to make this happen.

Let me now turn to NSF's role in fostering improvements in STEM education. I begin by stating clearly that we must set aside any notion that NSF's education programs are either subservient to or in competition with its research programs. NSF's education and research missions are mutually supportive. NSF is uniquely

situated to bridge the gap between scientific and education communities, from the K-12 level to graduate school and beyond.

NSF's role should be to expand our knowledgebase, by providing the answers to the tough questions we wrestle with in STEM education, like how to best train struggling teachers, how to outfit the best possible science laboratories, and how to hook more of the best and brightest young minds on careers in science.

In responding to the STEM education challenge, we need to do what this country has done so well, assemble a world-class research effort at NSF with the resources necessary to produce real progress. Last year, ACS supported a provision in the Senate's broad competitiveness package that would require that funding increases in NSF's Education and Human Resources Directorate be proportional to overall increases in the Foundation budget. This way, as NSF grows, under the proposed American Competitiveness Initiative, research and education will grow together.

We understand that the Committee is now contemplating a similar provision for NSF's undergraduate programs, a step we enthusiastically support. NSF also needs to be more effectively organized to facilitate interdisciplinary research. As rapid scientific advances have opened new arenas and blurred the boundaries between traditional disciplines. An increasing number of chemists now work in areas that may not even have been considered chemistry as little as a decade ago.

A theme we emphasize at the ACS is that chemistry is an enabling science, meaning that breakthroughs in chemistry provide a foundation for the many advances we see in other fields, or to quote the former NIH Director, Harold Varmus: "Medical advances may seem like wizardry, but pull back the curtain, and sitting at the lever is a high energy physicist, a combinatorial chemist, or an engineer." This is also true of faster computers, the explosion of nanotechnology, and batteries for hybrid cars, all examples of the interdisciplinary nature of chemistry.

Today's grand challenges of energy independence, national security, and improved health care, will require sustainable solutions. Such solutions will be found through a collaborative and interdisciplinary paradigm, a paradigm that NSF can help develop and drive. NSF doesn't necessarily need to create a new program to deal with this particular aspect of the research enterprise. One avenue of progress could be to broaden the backgrounds of NSF's various review panels, advisory boards, and program officers.

When I am not serving in my role as President of the American Chemical Society, my day job is Leader of Technology Partnerships at the Rohm & Haas Company. The corporate environment has placed a great premium on research that yields results in the shortest time possible, so must industry research is of the applied variety, and typically focuses on projects that yield near-term commercialization. Since NSF is a primary source of basic research funding, it makes sense for industry to partner in a symbiotic way with the NSF and its university grantees on projects that leverage benefits from both the applied and the basic sides of the research house.

We understand that the Committee is considering a change to NSF's merit criteria that would give special consideration to pro-

posals that include partnerships between academic researchers and industrial scientists. That focus on areas that are specifically identified to improve our economic competitiveness, and the ACS supports such efforts as a means to encourage more industrial collaborations.

So, in conclusion, I would like to thank the Subcommittee for the opportunity to represent the views of the American Chemical Society and the scientific community here today. We have been deeply engaged in this debate about the future of American competitiveness, and we plan to see it through.

We thank you for taking swift action to ensure NSF has the tools to play its part. Thank you.

[The prepared statement of Dr. Hunt follows:]

PREPARED STATEMENT OF DR. CATHERINE T. HUNT

Introduction

Chairman Baird, Ranking Member Ehlers, and distinguished Members of the Subcommittee:

Good afternoon.

As President of the American Chemical Society, or ACS, it is my great pleasure to address the Committee on behalf of our more than 160,000 members as you consider reauthorization of the National Science Foundation (NSF).

Our Society was congressionally chartered in 1937 to advance chemistry in all its branches, promote scientific research and inquiry, and foster public welfare and education. We have long been strong supporters of the National Science Foundation, an agency of particular importance at this critical time in our nation's history.

As the Members of this committee are keenly aware, the United States faces threats to its economic and technological leadership from countries that have made monumental investments in educating their workforces as well as investing in research and development—thus becoming emerging and growing innovation incubators—with the result that they are capitalizing on international economic and intellectual investment.

Our heretofore unmatched capacity to innovate—to create new products and processes, markets, and industries that change the world—depends on three critical and interdependent elements:

- Novel new ideas that flow from a strong, diverse, basic research enterprise;
- A creative, well-trained, and determined workforce; and
- An environment that not only fosters, but facilitates, an innovation pipeline that moves ideas from conceptualization, to invention to market.

The NSF is unique amongst federal research agencies in that it broadly supports science and engineering—across all disciplines. The history of this unique mission is instructive to our consideration about the future of the agency. NSF grew out of the international and global challenges of the mid 20th century.

Allow me to quote from *NSF: A Brief History,* a 1994 report that detailed the formation and history of the Foundation:

> *President Truman signed the bill creating the National Science Foundation on May 10, 1950. The act provided for a National Science Board of twenty-four part-time members and a Director as chief executive officer, all appointed by the president. Among other things, the law directed the agency to encourage and develop a national policy for the promotion of basic research and education in the mathematical, physical, medical, biological, engineering, and other sciences; to initiate and support basic scientific research in the sciences; and to evaluate the scientific research programs undertaken by agencies of the Federal Government. Organizationally, the Foundation could create whatever divisions were necessary to carry out its activities, but the act specified that four divisions had to be included: medical research; mathematical, physical, and engineering sciences; biological sciences; and scientific personnel and education. The latter division was responsible for scholarships and graduate fellowships.*

It took five years of debate between Congress, the Truman Administration, and the scientific community to establish an agency that truly supports the scientific enterprise in the United States by focusing concurrently on broad support for research

and university science and for science education. NSF and its unique mission are equally relevant today as the agency plays a central role in our national response to the innovation challenges of the 21st Century.

NSF provides about one-fifth of all federal funding in support of basic research at America's colleges and universities. The Foundation also plays an absolutely essential role in addressing challenges in the area of science, technology, engineering, and mathematics (or "STEM") education from kindergarten through graduate school and beyond.

The NSF has also been charged with the highly important and extremely challenging mission of promoting science on a broad basis and bridging the gulf between scientific advances and public understanding.

A hardworking and entrepreneurial American workforce, coupled with aggressive federal and private investment in scientific and technological research has achieved such notable milestones as sending a man to the moon, harnessing the atom and sequencing the human genome. These achievements, as well as reams of other examples, have long supported the economic underpinnings of the U.S. economy that is the envy of the world.

But our future economic leadership is not something we can take for granted. As the much quoted National Academies *Gathering Storm* report warns, we need to redouble our efforts to revitalize our science, technology, engineering and mathematics (STEM) education system to generate future innovators, while at the same time making a parallel investment in our federal research and development capabilities to serve as the incubator to bring new ideas and innovations to fruition.

Education and research and development go hand-in-hand as among the most important pillars of American innovation that can sustain our global competitiveness.

NSF has a vitally important role to play in both education and research and development, especially in the years ahead as we rise to meet the unprecedented threats to our global economic strength and competitiveness. With these grand challenges in mind, I welcome this chance to offer our Society's observations on a few of the key opportunities that NSF can pursue to achieve its overall goals during the next five years.

Cultivating Young Investigators

I turn first to the question of how NSF might take a more active role in developing our future scientific excellence by supporting young investigators—our nation's future innovators.

We applaud the Committee for taking action last month to advance legislation related to this specific topic. The *"Sowing the Seeds through Science and Engineering Research Act,"* H.R. 363, would strengthen the NSF CAREER grant program by tying CAREER grant funding to the overall NSF budget—so that as NSF grows, so will its commitment to support young investigators—and also by helping universities better identify and target the needs of young investigators.

It has never been a great secret that young minds with fresh ideas are essential to advancing our understanding of science, so it is of paramount importance that we ensure that new investigators have good opportunities to compete for funding to enable them to establish their research programs in academe and elsewhere.

We have long supported efforts by the Committee and others to expand the NSF CAREER grant program, which targets resources for young investigators. CAREER grants are clearly one of the best mechanisms for giving young investigators a chance to compete against their peers for vital early support funding.

Unfortunately, as the overall research budget for the physical sciences and NSF in particular has been effectively flat over the last several years—at least until very recently—it has forced an unfortunate competition between more established researchers and new young investigators for grants, with the result that many new investigators are finding it often difficult—and sometimes impossible—to the find the funding necessary to establish innovative research programs of their own.

One reason that the American Chemical Society has strongly supported the American Competitiveness Initiative and other efforts that recognize the critical link between support for basic scientific research activities and our future economic competitiveness is that by increasing the size of the grant pool for research in general, we avoid—pardon the analogy—robbing "Peter" to pay "Paul."

In reality we need to support both "Peter" and "Paul" if we intend for our country to keep producing the tremendous array of innovations that will keep our economy growing in the decades to come.

We have also come to understand that while most young investigators are equipped with cutting edge technical and research skills, they are often poorly prepared for their teaching responsibilities and frequently ill-equipped to deal with the

"non-research" tasks that they must take on, including grant writing and other essential academic endeavors.

One project supported by the American Chemical Society in this area is the Preparing Future Faculty (PFF) Program, which was started in 1993 as a partnership between the Council of Graduate Schools and the Association of American Colleges and Universities (AAC&U) and funded in part through an NSF grant.

The PFF program, which now reaches more than 300 partner colleges and universities, has helped increase our understanding of the expectations of new faculty with regard to teaching, research, and university service are often at odds with the skills that doctoral graduates have developed during their two decades of educational experience. Several years ago, the original PFF partners teamed up with the American Chemical Society and other professional societies to participate in an NSF funded extension of PFF to create a "Shaping the Preparation of Future Science and Mathematics Faculty" program at five universities across the country. This latest project brings large research universities and smaller colleges into partnerships that provide an environment for graduate students to learn about the full range of faculty roles and responsibilities in teaching, research and service.

What we are hoping to achieve is a better understanding of how to prepare future faculty in the inter-related chemistry, physics, mathematics, and computer science fields to be successful researchers. We encourage NSF to continue to support projects like this that deal with the "human capital" side of the young investigator equation.

But well prepared new faculty will not help power the engine of American innovation without the means to bring their creative ideas into reality—and for this we must address the funding side of the equation as I have emphasized already.

Improving K–12 STEM Education

I would like to touch now on NSF's role in fostering improvements in STEM education at the K–12 and university level.

Let me state clearly that NSF must recognize that its educational mission is every bit as important to the Nation's future as its research mission.

We must set aside any notion that NSF's education programs are either subservient to or stand in competition with its research programs. NSF's education and research missions are mutually supportive, and play key, unique roles in building our nation's scientific and technological capacity.

Last year, we supported a provision in the Senate's broad competitiveness package that would require funding increases in NSF's Education and Human Resources (EHR) Directorate that are proportional to the overall increase in the Foundation's budget, so that as NSF's resources grow under the proposed American Competitiveness Initiative, research and education will grow together.

It is our understanding that the Committee is contemplating a similar provision while reauthorizing NSF's undergraduate education programs, a step that our Society enthusiastically supports.

One way that the American Chemical Society promotes excellence in chemistry education for undergraduate students is through our approval of college and university chemistry programs. Graduates from ACS-certified programs must often complete requirements that exceed those of the degree-granting institution. The certified degree program establishes that the student has completed an integrated, rigorous program that includes laboratory experience and the development of the professional skills needed to be an effective chemist. In addition to the direct benefits to students, the university program approval process provides a mechanism for departments to evaluate their program, identify areas of strength and opportunities for change, and leverage support from their institutions and external agencies.

Given the tremendous complexity of the educational challenges our country faces, I cannot emphasize strongly enough that NSF is uniquely situated as the agency best-suited to bridge the distance between the scientific and education communities. If, in responding to the math and science challenge our nation faces, we do not take full advantage of the unique strengths of NSF, we will be making a mistake.

There are many government agencies that play vital roles in math and science education, but the National Science Foundation should play the lead role. There is little doubt that NSF is one of the premier research institutions in the world, or that maintaining this position is a point of pride for the Foundation. I think it should also proudly hold the title of being the world's leader in educational innovation, helping future scientists more effectively deliver scientific knowledge to eager young minds.

In order to achieve this, we must expand our research efforts in science and math education. We need new technologies, new curricula, new resources and content materials, and most of all, new thinking on this subject. In other words, we need to

leverage what NSF does best—expand our knowledge base by funding the best possible educational research. The Nation has an ongoing need for research and innovation in math and science education, because, as we extend scientific and mathematical knowledge, develop new instructional technologies and uncover more about human learning, we must apply this new information to improve student learning.

Creating the world's best classrooms, teacher preparation programs and science learning methods is going to require a structured, focused research effort on a fairly large scale. We do not know what will work best in every U.S. classroom.

Education, in general, and math and science education in particular, is a very complex undertaking involving a large number of variables. Therefore, we need to do what this country does so well: assemble a world-class research effort at NSF with the resources necessary to produce real progress in an area of national importance.

NSF must clearly be the lead agency in undertaking this crucial research task.

On Interdisciplinary Research

I would now like to address the subject of interdisciplinary research. Let me start by pointing out something that is obvious among chemists, but may be less so outside of our discipline: The field of chemistry has dramatically changed—and it is still changing.

An increasing number of chemists now work in areas that previously were beyond our normal scope and might not have even been considered chemistry as little as a decade ago. The rapid science and technology advances of the last few years have not only opened new arenas, but the boundaries between traditional disciplines have blurred. This presents new challenges to research agencies that are tasked to identify and support the best science—which has traditionally been found along clear disciplinary lines.

Today's studies are leading to new fundamental discoveries and an expansion of the boundaries of molecular science that has given way to a bewildering increase in the need to comprehend and integrate information and techniques across diverse disciplines.

A theme we emphasize at the American Chemical Society is that chemistry is an "enabling science"—the idea that breakthroughs in chemistry underpin many of the advances we see in other fields. Faster computers, the explosion of nanotechnology and batteries for hybrid cars are prominent examples of this.

To quote former National Institutes of Health (NIH) Director and Nobel Laureate Harold Varmus: "Medical advances may seem like wizardry. But pull back the curtain, and sitting at the lever is a high-energy physicist, a combinatorial chemist, or an engineer."

Thus, the grand challenges of today-energy, food, water, security, health care—are interrelated and interdependent. These challenges will require strong collaborations between scientists and engineers in universities, industry, and national laboratories—and they will require us to focus on sustainable solutions. However, this emerging collaborative, interdisciplinary and sustainability paradigm for scientific endeavors is still relatively new.

In 2005, our Society conducted a comprehensive survey of its members that identified "continuing education in emerging and interdisciplinary fields" and "programs to encourage greater collaboration among chemists internationally; across disciplines; and across industrial, academic, and government" as two high priorities from a diverse list of more than 13 different proposed new initiatives. These subjects barely registered in a similar 2001 survey.

As the importance of such interdisciplinary research continues to increase, the scientific grant system must adapt to this new paradigm.

The challenge of the federal research agencies will be in moving toward a grant structure that maximizes scientific advances by supporting interdisciplinary research. Currently this is done by establishing initiatives at the borders of disciplines, which provides a new set of limitations to replace the traditional disciplinary boundaries.

The most effective way to support basic research, particularly in chemistry, is the individual-investigator or small-team grant. Any solution to the challenge of promoting interdisciplinarity must preserve the strength of that mechanism, which traditionally has considered and awarded grants along disciplinary lines. This will require a long-term concerted effort and considerable patience.

We encourage NSF to watch the NIH experiment to award grants to a small number of co-equal principal investigators. This will likely have the effect of encouraging both collaboration and interdisciplinary cooperation.

NSF doesn't necessarily need to create a profusion of new programs to deal with this particular aspect of the research enterprise. One avenue of progress could be

to make a concerted effort to identify ways to broaden the backgrounds of the members of NSF's various review panels and study sections and also the appropriate program officers to include more individuals with experience, enthusiasm, and new ideas for approaching interdisciplinary research.

One activity that the American Chemical Society has undertaken to promote interdisciplinary research in this area has been to support the Bridging the Sciences Coalition, a group of more than a dozen scientific societies and pharmaceutical companies—representing over 250,000 scientists—that is focused on supporting deep innovation in physics, chemistry, engineering, mathematics, and computer science—the "bridging" sciences—that must interface with biology and medicine to enable significant biomedical advances.

Without getting too much into the details, this "bridging" initiative seeks new federal resources to support research in these boundary fields as a means for pursuing distinct and unmet opportunities in the biomedical sciences.

As you would expect, starting new interdisciplinary research initiatives begins by clearly articulating the nature of the new research opportunity, the potential for new discoveries, and the tools and resources that are required.

We envision support for this "bridging science" initiative to come through a federal structure that combines the biomedical research cachet of NIH, the discipline-driven breadth of NSF, and the physical science depth of the Department of Energy—and we have met with progress on this front during the recent NIH reauthorization process.

While undertaking such broad collaborative efforts to bring together a productive partnership across agencies can be challenging, this is the kind of effort we need if we are to truly improve our capacity to capture the value that is inherent in interdisciplinary research NSF is ideally suited to promoting cross-disciplinary research because, as I mentioned before, the Foundation already supports science and engineering broadly, across all disciplines.

Along these same lines, the Committee reported legislation in the last Congress that would authorize the NSF to "establish a program to award grants for long-term, potentially path-breaking, basic research designed to simultaneously advance the physical and non-biomedical life sciences"—a provision that we supported.

On the administrative side, the Foundation has established several interdisciplinary project offices within its divisions and directorates. We note that the FY 2008 budget proposal for NSF would support the creation of a new, multi-disciplinary center for environmental, health, and safety research—a development we encourage.

The Committee has done an excellent job in the past to ensure that NSF has the flexibility to make alterations in its administrative organization to deal with the evolving nature of science—and the American Chemical Society encourages you to continue to empower NSF with the tools and flexibility necessary to allow it to fulfill this aspect of its important national mission.

At the end of the day, it is clear that as NSF continues to grow through the American Competitiveness Initiative and the strong support of the Members of the Committee, the Foundation's role in supporting interdisciplinary research must also expand and that the agency must adjust its institutions and structure to deal with the changing nature of scientific research.

Encouraging Industry Partnerships

The final topic I would like to speak to is that of how NSF might better leverage its partnerships with business and industry.

When I am not serving in my role as president of the American Chemical Society, my day job is as Leader for technology partnerships at Rohm and Haas Company, where I focus on building collaborations across companies, academia, government agencies, and private foundations.

In the corporate environment, the financial decision-making structure places a great premium on research that will yield results in the shortest possible time frame. So the vast majority of industry funded research is of the applied variety, typically focused on ideas that have potential for near term commercialization.

However, as this recent national debate on innovation and competitiveness has so clearly demonstrated, basic research in the physical sciences is one of the true engines that drives the long-term prosperity of our economy if it can be converted into the new products and industries that revolutionize our world.

Since NSF and other federal research agencies are the primary sources of basic research funding, it makes good sense for industry to partner in a symbiotic way with the agencies and their university grantees to collaborate on projects that can benefit from combining expertise from both the "applied" and "basic" sides of the research "house."

We understand that the Committee is considering a change to NSF's merit review criteria that would give special consideration to proposals that include partnerships between academic researchers and industrial scientists and engineers and that address research areas that have been identified as having high importance for future national economic competitiveness.

The ACS would support such efforts as a means to encourage more industrial collaborations through the NSF grant structure. As a final, I would also like to observe that in thinking about the question of how to support young investigators that I addressed earlier, it is also valuable to encourage new investigators to pursue collaborations and partnerships with industry—possibly as an a provision of the CAREER grant program.

Conclusion

In conclusion, I would like to thank the Committee for the opportunity to represent the views of the American Chemical Society and the scientific community here today.

We at the American Chemical Society have been deeply engaged in the evolving debate about the future of American competitiveness that has so dramatically unfolded over the last couple of years. This "competitiveness" movement is still picking up steam and we plan to see it through to a new era where our nation's technological leadership is again confirmed and renewed.

We see the process of NSF reauthorization as a key component of this debate and we applaud the Committee for taking swift action to complete your work on this front.

Let me conclude by touching on that old cliché that history tends to repeat itself, as illustrated by something the very first President of the American Chemical Society said at a time when another great technological ground shift—the Industrial Revolution—was shaking the world:

> *"Mankind has made the discovery that science is the great civilizing agent of the world. Let us continue our labor unobtrusively, conscious of the integrity of our motives, conscious of the portentous change in the thought of the world, conscious of the irresistible power that is behind us."*

Thank you.

BIOGRAPHY FOR CATHERINE T. HUNT

Dr. Catherine "Katie" T. Hunt is Leader, Technology Partnerships for Rohm and Haas Company, where she builds collaborations between the company, academia, government agencies, and private foundations. Since creating the unit in 2002, she has helped secure multi-million dollar grants from federal agencies to improve collaboration across all sectors of the chemical enterprise. In 2002, Dr. Hunt acted as a member of the steering committee for the "Nanomaterials and the Chemical Industry Roadmap Workshop," a collaborative effort between the Department of Energy Efficiency and Renewable Energy (DOE/EERE), the National Nanotechnology Initiative (NNI), and the Chemical Industry Vision 2020 Technology Partnership. As a result of this workshop, Dr. Hunt co-authored the *Chemical Industry R&D Roadmap for Nanomaterials by Design: From Fundamentals to Function.*

Dr. Hunt began her career in industry with Rohm and Haas Company in 1984 after completing an NIH Postdoctoral Fellowship at Yale University. Since then, Dr. Hunt has held a variety of positions at every level of the company from Senior Scientist in Analytical Research (1984) to Philadelphia Plant Laboratory Manager (1991) to Director of Worldwide Analytical and Computational Competency Network and Technology Development (1998). She was named to her current position in 2002.

Dr. Hunt holds an A.B. in Chemistry *(Cum Laude)* from Smith College, Northampton, MA, and a Ph.D. in Chemistry from the University of California, Davis. She has authored 13 papers, one book chapter on Metallothionein.

Professional Organization Leadership

Dr. Hunt is the 2006 President-Elect for the American Chemical Society. She will serve as President in 2007 and as a member of the board of directors from 2006–2008. She has been a member of the society since 1977. She is also an active member of the American Association for the Advancement of Science, the International Union on Pure and Applied Chemistry, and Sigma Xi. Dr. Hunt serves on the Board of Directors of the Council for Chemistry Research and was a participant in the Vision 2020 Industry Group.

Over her professional career Dr. Hunt has received many awards including being a member of the Women in Science Delegation to Cuba (2001); Best Paper Award from INDA, Association of Nonwoven Fabrics Industry (1997); Rohm and Haas Company, S.J. Talucci Quality Award (1996); and NIH Postdoctoral Fellowship (1982–1984)

American Chemical Society

The American Chemical Society is a nonprofit, member-governed organization that consists of more than 159,000 individual members at all degree levels and in all fields of chemistry and chemical engineering. The organization provides a broad range of opportunities for peer interaction and career development, for a wide range of professional and scientific interests. As the world's largest scientific society and in keeping with its congressional charter. ACS advances the chemical enterprise, increases public understanding of chemistry, and brings its expertise to bear on state and national matters.

Chairman BAIRD. Thank you, Dr. Hunt. Dr. Ford.

STATEMENT OF DR. MARGARET F. FORD, PRESIDENT, HOUSTON COMMUNITY COLLEGE SYSTEM, NORTHEAST

Dr. FORD. Good afternoon, Chairman Baird, Ranking Member Ehlers, and Members of the Subcommittee on Research and Science Education. I thank you for the opportunity to testify before your subcommittee today. My name is Margaret Ford, and I am President of the Houston Community College, Northeast, and a board member of the American Association of Community Colleges.

AACC serves as the national voice for the country's 1,202 community colleges. Counting more than 90 percent of these institutions as its members, on behalf of AACC and the students who benefit from competitively funded programs provided by the National Science Foundation, I sincerely thank you, Chairman Baird and Ranking Member Ehlers, for your interest in the efficacy of technical training at two year colleges through the Advanced Technological Education Program, and the success of community colleges in delivering STEM education.

Now, my testimony today is based upon my employment with the Houston Community College, where I have served in various administrative roles for over twenty years, and where I have served as President of the Northeast College for ten years. The Houston Community College is the third largest singularly accredited community college in the Nation. There are six regional colleges within the district which serves 56,000 students per semester in academic transfer, workforce, and continuing education courses. Houston Community College offers over 75 technical programs, including a long list of STEM programs, including biotechnology, chemical process technology, and computer systems networking.

As you develop NSF reauthorization legislation, please be mindful that community colleges are crucial to educating the Nation's technical workforce, increasing the pipeline of students in STEM majors, and preparing and providing professional development for the Nation's K–12 STEM teachers. The Nation's global competitiveness in STEM fields has, as the Committee is well aware, been the subject of a tremendous amount of discussion in recent years. One important facet of this issue is often overlooked, the education of the Nation's technical workforce. We are absolutely delighted that you have included the technical component, and we thank you very much for that.

There are many STEM-oriented jobs that, at least at the entry levels, require some post-secondary education, but not necessarily a Bachelor's degree. These are the people that keep our laboratories running, who oversee the operations of advanced manufacturing facilities, and provide information technology support to the Nation's businesses. The need to produce more of these skilled workers, which continues unabated today, led to the creation of the Advanced Technological Education Program in 1992. Now in its fourteenth year of funding, the Program has grown from $10 million to over $45 million today. The ATE Program serves its primary goal of improving and expanding technician education through 33 centers and approximately 250 active projects in fields such as aerospace technology, biotechnology, advanced manufacturing, environmental technology, and a host of others.

ATE centers and projects create extensive partnerships with businesses and industries, other two year colleges, four year colleges and universities, and secondary schools. Nearly 800 projects have been supported by the ATE Program through the years, reaching 320,000 two year college students, and thousands of high school and university students.

HCCs, the Houston Community College's ATE Project serves the local energy industry by supporting articulation partnerships, so students can complete the two year process technology degree, and then transfer to a four year process technology program. Local industry is involved through an established alliance with the Gulf Coast Technology Articulation Partnership, that represents 100 industry members and 20 colleges. The focus of our ATE grant is to provide AAS degree holders in process technology an opportunity to continue their education towards a baccalaureate degree. Given the industry demand for higher credentials, this is really critically important.

The Project includes a significant outreach component and support systems to attract under-represented students; 32 of our students have completed the program, and have transferred to McNeese State University in Lake Charles, Louisiana. The program is enhanced by a Two Plus Two Plus Two Partnership, where dual credit is available to eligible high school juniors and seniors, free of charge, through a waiver by a Board of Trustees.

By all accounts, the ATE program is serving the needs of its constituents very, very well. AACC supports reauthorization of the ATE Program, to reaffirm the strong support that this committee and Congress as a whole has shown for this program over the years.

Beyond ATE, any serious effort to increase the number of students in STEM majors and entering STEM fields, particularly those from under-represented minority populations, should include a significant focus on community colleges. Community colleges enroll 46 percent of the Nation's undergraduates, and higher percentages of minority and first generation college students, than any other sector of higher education. 44 percent of students who obtain a Bachelor's or a Master's degree in science and engineering-related fields complete, at some point, at the community college. AACC supports reauthorization of the STEM Talent Expansion Program in H.R. 362 and the coming legislation. I believe that

there is room for a greater role for community colleges in this program, or perhaps even a separate program focused on the unique role of community colleges in this area.

Community colleges are also crucial to the preparation and professional development of K–12 STEM teachers. Up to 40 percent of teachers, and perhaps, significantly more, have completed some of their STEM coursework at community colleges. Teacher preparation and certification are significant activities at my institution. For example, 1,521 students enrolled in our teacher education program that leads to an associate of arts in teaching degree, and is fully articulated with four year institutions. HCC also offers an alternative teacher certification program that prepares individuals for certification in elementary and secondary levels of teacher education, including several STEM fields.

The NSF has recognized the importance of community colleges to growing the numbers of qualified STEM teachers, and I believe there is room for growth of the agency's ongoing support for community colleges in this area. For this reason, I applaud the expansion and modification of the Robert Noyce Scholarship Program. I believe that further refinement of the language in that legislation may be needed to effectively bring community colleges into the fold of this important program. I also welcome the separate authorization for the Teacher Institutes for the 21st Century.

So, in closing, the NSF has become a key source of federal support for our institutions and students, and I look forward to our continued partnership. As reauthorization moves forward, I believe there is an opportunity to build upon this partnership to ensure that community colleges are fully utilized in increasing the Nation's STEM competitiveness.

Chairman Baird, Ranking Member Ehlers, Members of the Subcommittee, I thank you for the opportunity to the Research and Science Education Committee today. Thank you very much.

[The prepared statement of Dr. Ford follows:]

PREPARED STATEMENT OF MARGARET F. FORD

Good afternoon, Chairman Baird, Ranking Member Ehlers, and Members of the Subcommittee on Research and Science Education. I thank you for the opportunity to testify before your Subcommittee today. My name is Margaret Ford, and I am President of the Houston Community College–Northeast and a Board Member of the American Association of Community Colleges (AACC).

I have the great privilege of serving on the AACC Board and working with Dr. Ed Coulter, Chair of the AACC Board of Directors, 31 fellow Board Members who were elected to the Board, and AACC President Dr. George Boggs. AACC serves as the national voice for the country's 1,202 community colleges, counting more than 90 percent of these institutions as its members. On behalf of AACC and the students who benefit from competitively-funded programs provided by the National Science Foundation, I sincerely thank you, Chairman Baird and Ranking Member Ehlers, for your interest in the efficacy of technical training at two-year colleges through the Advanced Technological Education (ATE) Program and the success of community colleges in delivering STEM education.

Community colleges play a major role in educating residents of the Nation's communities. Did you know that community colleges enroll 11.6 million students annually? Forty percent of the students who enroll at community colleges are full-time students. The majority (60 percent) of students who enroll at community colleges, however, are part time students. The part-time students are usually employed, many full-time; they have families or other obligations, and they recognize the importance of a college degree to improve their earning potential, their job security, and their upward mobility on their jobs. An important distinguishing feature of community colleges is that 46 percent of all U.S. undergraduates enroll at commu-

nity colleges; they are first-time freshmen who, according to national reports, perform just as well or better academically when they complete their associate's degree and transfer to a four-year university as students who began at the university level as freshmen.

These data, in part, illustrate why community colleges provide the comprehensive educational programs to facilitate student success—whether for academic transfer to a senior-level institution or for technical degree completion that will lead to employment. In either case, the community college Open Door provides access for millions of students who might not initially be accepted to a senior-level institution as a freshman. Community colleges prepare students with the tools to succeed and create a sequential pathway, for many students, to senior-level institutions. Community colleges enroll a higher percentage of minority students than any other sector of higher education. 47 percent of Black; 55 percent of Hispanic; 47 percent of Asian/Pacific Islander, and 57 percent of the country's Native American undergraduates are enrolled at our institutions, where the average student age is 29.

As you consider reauthorization of the National Science Foundation, we appreciate your acknowledgment that some community college students may not have all competencies required for success when they enroll at our institutions, but they will have attained all of the competencies prior to exiting our institutions. In that spirit, I acknowledge the testimonies of National Science Foundation Board Chairman, Dr. Steven Beering and NSF Director Dr. Arden Bement. Dr. Beering stated, and I agree, that the most effective partnership with industry is accomplished through training undergraduate and graduate students who in turn enter the private sector with advanced skills in science and engineering fields." Community college students, many of whom enroll to complete technical Associate in Applied Science (AAS) degrees, are employed in industry positions before they graduate from our institutions. This success in placement is due, in large part, to the high caliber of training that occurs, the competencies and skills that students attain, and the close alliance that community colleges have with industry advisors in the development and implementation of all AAS degree programs. Thus, community colleges are poised, Mr. Chairman, to produce more student completers with the advanced skills in science and engineering fields to help achieve the goals that you mentioned of increasing global competitiveness and students' interest in math and science.

My testimony today is based upon my employment with the Houston Community College where I have served in various administrative roles for over twenty years and where I have served as president of the Houston Community College–Northeast for ten years. Prior to beginning my testimony, I acknowledge the fine work of the Chancellor of the Houston Community College, Dr. Mary Spangler; the dedication of the faculty and staff teams at all six HCC colleges, and the District personnel who help to create the outstanding student successes that we experience in carrying out the vision of our Board. I particularly acknowledge Dr. John Galiotos, who has done an exemplary job in creating new Science and Technology Programs at the Northeast College to train technicians for employment in the energy sector.

NSF support for community colleges is a relatively recent phenomenon. No substantial NSF funds went directly to community colleges before the first year of funding for the ATE program in FY 1994. In FY 2006, NSF provided over $80 million in support of community and technical colleges, primarily through the ATE program, but also through several other initiatives. The NSF has become an important source of support for community colleges, and it is safe to say that the NSF's attitude towards community colleges has evolved from one of reluctant acknowledgment to enthusiastic partnership.

Chairman Baird and Ranking Member Ehlers, given the introductory information provided, my testimony will address the specific areas noted in your invitation: (1) to provide a brief overview of science, technology, engineering and technician training programs at the Houston Community College—including partnerships with local industries and the number of students we reach through these programs, (2) to describe the NSF-funded Advanced Technological Education (ATE) program at the Houston Community College–Northeast and identify its markers of success. As requested, I will provide specific suggestions for NSF on how to improve its ATE program, and (3) to describe HCC's relationship with the NSF outside of the ATE program. Finally, I will respond to your questions that ask whether we believe that NSF is adequately serving the science and technology education and research needs of U.S. community colleges, and what might NSF do differently or better, other than providing more money, to serve community college needs.

In addressing these questions, I hope to make clear that as it develops NSF reauthorization legislation and in its endeavors in general, the Committee should be mindful of the vital role that community colleges play in STEM education. In particular, community colleges are crucial to educating the Nation's technical work-

force, increasing the pipeline of students in STEM majors, and preparing and providing professional development for the Nation's K–12 STEM teachers.

Overview of Houston Community College Service-Area Demographics

As background information, the Houston Community College is the third largest singularly accredited community college in the Nation. There are six regional colleges within the District which serves 56,000 students per semester in academic transfer, workforce, and continuing education courses. The College District has achieved excellence in many areas of student success. Some of those areas include the rate and percentage of student transfer, student certificate and degree completion in technical program areas, the number of exemplary technical programs as designated by the Texas Higher Education Coordinating Board, rate of student job placements, pass rate on State Exams, employer satisfaction, and the high level of student satisfaction in the "Report of Findings" in the Community College Student Engagement Report.

The Houston Community College District includes seven school districts with a total population of more than two million residents and slightly over 1.5 million residents comprising the adult population. The ethnicity of Houston Community College's service area is 22.5 percent African American, 33 percent Hispanic, 7.1 percent Asian, 37.1 percent White, and 0.3 percent other. Within the Service Area Population, the educational attainment for residents 25 years and older is as follows: 26.3 percent have no high school or GED, 21.1 percent have high school or a GED, and 52.6 percent have high school plus college, and 8.7 percent enrolled in college. In the Northeast College Regional Service area where I serve as President, there are 350,000 residents. The ethnicity reflects that 19.7 percent are White, 30.9 percent are African American, 48.5 percent are Hispanic, 0.7 percent is Asian or Pacific Islander, and 0.1 percent is other. Within the service area, the educational attainment for residents 25 and older reflects the following: 33.3 percent of the residents lack a high school diploma or GED, 27.7 percent have a high school diploma, and 18.8 percent have high school and some college, and 21.2 percent have a degree (associate, Bachelor's, graduate or professional degree). These demographics are important because they help focus the training opportunities for the community and the support services needed to ensure student success.

Overview of Science, Technology, Engineering and Technician Training at the Houston Community College

The Houston Community College offers over 75 technical programs in diverse areas under the leadership of Dr. Charles Hebert, Associate Vice Chancellor for Technical Education and Dr. Charles Cook, Vice Chancellor for Instruction. Below is a list of some of the programs and the number of student completers. All programs are industry driven and have industry advisors. There are 350 industry advisors in the Science, Engineering and Technology areas. In the area of Energy, there are two Energy Collaborative partnerships. One is with the Great Houston Energy Committee, and the other is with the Great Houston Energy Collaborative.

Below are the top ten academic programs by contact hours:

Biology
English
Mathematics, Developmental
Mathematics
History
Government
Guided Studies
Psychology
Intensive English
Chemistry

Below are the top ten technical programs by contact hours:

Corrections
Emergency Medical Technician
Computer Science Technology
Fire Protection Technology
Business Technology
Accounting
Business Administration

Associate Degree Nursing
Audio Recording Technology
Cosmetology

An abbreviated list of the Science, Technology, and Engineering Programs (including some in the health fields not typically funded by NSF) are listed below with the total number of graduates over a three-year period.

Abbreviated List	Graduates Over Three Years
Industrial Production Technologies Technician	28
Computer Engineering Technologies Technician	137
Drafting Design Engineering Technologist	91
Computer Systems Networking	27
Electronic Engineering Technology	102
Biotechnology	29
Chemical Process Technology	87
Health Information Technology – Medical Records	71
Pharmacy Technician	140
Nuclear Medicine Technology	133
Emergency Medical Technology	121
Surgical/Operating Room Technician	169
Radiography	146
Nursing	416
Business Technology	450
Fire Protection Technology	671

The Houston Community College has an increasing number of students completing Certificates and Degrees. In the 2005–2006 Academic Year, there were a total of 5,741 completers.

Academic Completers:	
Associate in Arts	1,242
Associate in Science	262
Core Curriculum Certificates	1,188

Associate in Applied Science Degree and Certificate Completers:	
Associate in Applied Science	731
Associate of Arts in Teaching	7
Level One Certificate	1,240
Level Two Certificate	41
CEU Certificates	5
Marketable Skill Achievers Certificate	755

The placement rates for graduates are high, and the satisfaction rate of employers is also consistently high.

Community Colleges Educate the Nation's Technical Workforce

The nation's global competitiveness in STEM fields has, as the Committee is well aware, been the subject of a tremendous amount of discourse in recent years, especially with the publication of popular books such as *The World is Flat* and seminal reports like the National Academies' *Rising Above the Gathering Storm.* Much of this discussion has been about the number of American students obtaining Bachelor's or advanced degrees in the STEM fields, and on the quality of K–12 STEM Education. These are both vital topics, and I will address the community college role in them below. However, there is another important facet to this issue which is

often overlooked, and that is the education and development of the Nation's technical workforce.

There are many STEM-oriented jobs that, at least at the entry levels, require some post-secondary education, but not necessarily a Bachelor's degree. These are the people that keep our laboratories running, man the floors of advanced manufacturing facilities, and provide information technology support to the Nation's businesses.

The need to produce more of these skilled workers, which continues unabated today, led to the creation of the Advanced Technological Education program. ATE was originally authorized by the *Science and Advanced Technology Act of 1992* (SATA), and first funded at $10 million in FY 1994. Now in its 14th year of funding, the program has grown to $45.4 million, and the Administration has proposed increasing ATE's funding to $51.6 million in FY 2008.

The ATE program is jointly administered at NSF by the Division of Undergraduate Education (DUE) and the Division of Elementary, Secondary and Informal Education (ESIE). NSF funds projects and centers across the Nation to carry out the ATE program's mission. Currently, the ATE program supports 33 national, regional and resource centers and approximately 250 active projects. Centers focus on systemic approaches to technician education, usually within a specific discipline, and are expected to have broad impact. Projects focus on specific aspects of technician education, such as standards development, curriculum development, and faculty development. The ATE program supports centers and projects in fields such as aerospace technology, biotechnology, advanced manufacturing, environmental technology, and a host of others. All centers and most projects create extensive partnerships with businesses and industry, other two-year colleges, four-year colleges, and universities and secondary schools. The ATE program supports curriculum development; professional development of college faculty and secondary school teachers; career pathways to two-year colleges from secondary schools and from two-year colleges to four-year institutions; and other activities. A secondary goal is articulation between two-year and four-year programs for K–12 prospective teachers that focus on technological education. The program also invites proposals focusing on applied research relating to technician education.

According to researchers at The Evaluation Center of Western Michigan University, which annually surveys ATE principal investigators, nearly 800 projects have been supported by the ATE program through the years, reaching 320,000 two-year college students, 48,000 high school students, and 6,000 students at baccalaureate institutions. More than 2,000 two-year college programs and 16,800 courses have been created, as well as hundreds of programs and courses at the secondary and baccalaureate level. More than 80,000 educators have received professional development. As you might guess from these numbers, the ATE program is the cornerstone of the community college–NSF partnership.

HCC's ATE Program

HCC's ATE project was funded by NSF in May 2004. The project supports articulation partnerships so students can complete the two-year Process Technology (PTEC) program and transfer to a four-year PTEC program. The focus of the grant is to improve the way technicians are educated for the workplace. Faculty development, industry involvement, and student engagement are core requirements in the professional development component of the program. The industry involvement is through an established alliance with the Gulf Coast Technology Articulation Partnership (GCTAP) that represents 100 industry members and 20 colleges. The intent of the partnership is to transition students from the Associate in Applied Science Degree to the Bachelor of Science in Engineering Technology Degree. The Principal Investigator is Dr. John Galiotos, Department Chair of Science Technologies and Manager of the Energy Institute at the Houston Community College–Northeast. The Co-Principal Investigators are Dr. Nikos Kiritsis, Ms. Dorothy Ortego, Ms. Carol Schulte, and Mr. James Dautenhan. HCC–Northeast, through this program, is one of the educational partners of the Center for the Advancement of Process Technology (CAPT), an ATE National Center of Excellence.

The focus of our ATE grant is to provide AAS Degree holders in PTEC an opportunity to continue their education towards a Baccalaureate Degree given the industry demand for higher level credentials. The project includes a significant outreach component and support systems to attract and retain Hispanic students. This outreach includes meeting with parents of high school students, developing promotional materials in Spanish, providing scholarships to students attending both institutions, developing yearly one-day workshops at each institution for counselors and high school teachers to become more informed about PTEC and to raise their student's awareness about the opportunities in PTEC, creating student cohorts that includes

mentoring support, and providing trips to McNeese State University to understand how job opportunities in PTEC are enhanced by obtaining a four-year degree.

Like nearly every ATE project, there is strong industry support for our ATE project and the larger partnerships in which it is involved. Industry partners supporting the partnership for the Gulf Coast Articulation include British Petroleum, Shell Chemical Company, NALCO Chemical Company, Berric Davis International, ExxonMobil, Chevron, Environ Test, Goodyear, Liquid Environmental, Halliburton, Emerson, Schlumberger, and Pasadena Refining. The work of GCTAP and the CAPT has had a profound impact on its industry partners. BP reports saving $16,000 per person in reduced overtime expenses and training time by hiring PTEC AAS graduates.

Additionally, PTEC graduates have a 37 percent better safety record than new hires. According to the NSF publication *ATE Centers Impact 2006–2007,* "representatives from BP and Shell Oil Co. have identified the core curriculum developed by CAPT for the PTEC degree as essential to the strength of their internship programs. Their long-term hiring projections now include the expectation that their PTEC internship programs will grow and that successful interns will increasingly fill full-time process technician jobs." This type of impact on the Nation's industries can be seen across the spectrum of the ATE centers and projects.

Thirty-two students have completed the Houston Community College program and have transferred to McNeese State University which is located in Lake Charles, Louisiana. McNeese State University was established in 1939 and is the largest comprehensive university in Southwest Louisiana—serving 9,000 students per year. Student-friendly features of the partnership allow students to pre-transfer and to co-enroll. The program is enhanced by a 2+2+2 partnership where dual credit is available to eligible high school juniors and seniors, via an HCC board-approved waiver of tuition and fees, to enroll in the AAS Degree Program in PTEC.

The positive outcomes, or markers of success, are derived primarily from the application of the partnership concept. Currently, application of the concept is underway as listed below:

- The University of Houston Downtown is using a similar format to develop articulation partnerships between the Biotechnology program at HCC and with their BS program in Biotechnology.
- The Sam Houston State University Criminal Justice program articulates with the HCC Public Safety Program using the GCTAP platform.
- Prairie View A&M University will use a similar platform to articulate the HCC Chemical Laboratory Technology Program with their Chemical Engineering Program.
- Bellingham College, Bellingham, WA, uses the platform to articulate with the Western Washington University BS program in Engineering Technology.
- The platform is used for the University of Houston College of Technology to articulate all of the HCC programs in the Science Technology Division with the University of Houston Engineering Technology Division.
- GCTAP is used as the model for articulation for a NSF/ATE grant on Stationary Fuel Cells education submitted by TATC–Waco, HCC–NE, and Alamo Community College.
- GCTAP is used as the model for articulations for a Center grant in Nanotechnology by Austin Community College in collaboration with HCC–Northeast Energy Institute.
- The GCTAP platform model will be used as the articulation platform for a new certificate in Advanced Manufacturing funded by a Carl Perkins grant from the State of Texas.

Reauthorization of the ATE Program

By all accounts, the ATE program as currently operating, and as originally authorized by SATA and modified by the *NSF Reauthorization Act of 2002,* is serving the needs of its constituents very well. The Evaluation Center at Western Michigan University, which annually surveys the ATE principal investigators to identify the key factors either contributing to or inhibiting program improvement, has generally found that none of these factors are "substantial enough to be addressed on a programmatic level for ATE as a whole." This finding backs the overall satisfaction with the program that we hear from the field. From our experience at HCC, I recommend that the ATE program continue to emphasize articulation between two-year and four-year institutions to increase the number of AAS to BAAS degree programs in STEM disciplines and in STEM Career Pathways. Increasing federal sup-

port for establishing such articulation agreements and other modes of cooperation between the sectors of higher education, both inside and outside the STEM areas, is one of AACC's top priorities in 2007.

AACC supports reauthorization of the ATE program to reaffirm the strong support that this committee, and Congress as a whole, has shown for this program over the years. In the past, NSF has indicated that $70 million would be required to achieve their preferred acceptance rate for ATE proposals. If this is still the case, we propose that this figure serve as the authorization amount for FY 2008, with increased amounts for succeeding years.

On a side note, the Western Michigan surveys identify "student recruitment" as the main "inhibitor" to ATE program improvement. Community colleges still find that, on many fronts, there is an awareness gap in regards to technical programs of study. Some students, parents, guidance counselors, and in some cases our colleagues at four-year universities still hold the outdated distinction between "higher education" on the one hand and "vocational education" on the other. While maybe not a subject for the reauthorization legislation, I would suggest that the NSF, perhaps in conjunction with other federal departments such as the Department of Labor and Commerce, increase their efforts to educate the public on the sophisticated nature of today's technical careers, in terms of their "respectability," attractiveness, and the benefits to be derived from them for the student; and also in terms of the serious academic preparation necessary to embark on careers in these areas.

Community Colleges Are Vital to Increasing the Nation's Pipeline of STEM Students

Any serious effort to increase the number of students in STEM majors and entering STEM fields, particularly those from under-represented minority populations, must include a significant focus on community colleges. A brief look at the numbers backs this assertion. As noted above, community colleges enroll 45 percent of the Nation's undergraduates, and higher percentages of minority and first-generation college students than any other sector of higher education. Even within the STEM fields, the numbers are striking: 44 percent of students who obtain a Bachelor's or Master's degree in science and engineering attended a community college at some point during their degree studies.

AACC applauded and has supported the STEM Talent Expansion Program (STEP) since its inception, and supports its reauthorization in the coming legislation. Currently, community colleges directly receive approximately 20 percent of the grants from this program, and are partners in a substantial number of the other grants. I believe that the facts I cited above support an even greater presence for community colleges in this program, or perhaps even a separate program focused on the unique role of community colleges in this area. In any case, AACC strongly supports substantial growth for this program both in its authorization and appropriations.

Another program that has been very important to community college efforts to grow the number of STEM students has been the NSF Scholarships in Science, Technology, Engineering and Mathematics, or S–STEM program (formerly CSEMS). This program makes grants to institutions of higher education to support scholarships for academically talented, financially needy students, enabling them to enter the workforce following completion of an associate, baccalaureate, or graduate level degree in science and engineering disciplines. Grantee institutions are responsible for selecting scholarship recipients, reporting demographic information about student scholars, and managing the S–STEM project at the institution. In FY 2006, community colleges and their students received nearly $18 million from this program, which is funded by the fees employers pay to obtain H–1B visas for skilled foreign workers.

HCC has an S–STEM (then CSEMS) grant that was funded in 2000 and refunded in 2004. Our grant has been quite successful in meeting the objectives established to (1) recruit and enroll 33 students a semester into an Associate of Science and Associate of Applied Science MET Scholarship Program; (2) retain at least 75 percent of participants to the completion of a degree and transfer to a baccalaureate degree program; (3) establish six paid summer internships in STEM fields for promising students in the scholarship program to increase collaborations with industry. The program is quite successful in increasing skilled employees in technical areas and increasing student retention and completion.

The goal of the grant was to target students who can commit to two years as a full-time student at HCC and retain them for transfer to a four-year institution to complete their degrees in the S–STEM areas. According to the Co-Principal Investigator, Dr. Kenneth Holden, there are 53 students active in the program who are

pursuing careers in engineering, biomedical engineering, electrical engineering, civil engineering, biotechnology, environmental science, mathematics, chemical engineering and computer science fields of study. Since 2000, there have been 45 graduates. All have transferred to a four-year university.

Community Colleges Are Crucial to the Preparation and Professional Development of K–12 STEM Teachers

The anticipated demand for new teachers in the near future is daunting. It has been estimated that 2.5 million new teachers will be needed over the next decade to replace retirees, and deal with high attrition rates and population growth. The issue is not just one of quantity, as the requirements for high-quality teachers and paraprofessionals found in the *No Child Left Behind Act* also make it one of quality. This problem is especially acute in STEM fields. In dealing with this looming crisis, no stone must go unturned in recruiting and educating more qualified teachers, both from our student bodies and from the professional ranks.

While definitive numbers are hard to come by, various studies have shown a tremendous community college role in the preparation of K–12 STEM teachers. These studies have indicated that up to 40 percent of teachers, and perhaps significantly more, have completed some of their STEM course work at community colleges. This is not surprising given the percentage of STEM degree recipients overall that study at community colleges.

Teacher preparation and certification are significant activities at my institution. HCC offers a Semester-Credit Hour Teacher Education Program. The education curriculum is designed to help students develop competencies in selected teaching skills that are basic to implementing the reflective decision-making model. As a prerequisite to entering the Teacher Education Program, a student must be considered "college ready." Students must have a passing score in Reading and English. The term-to-term completion shows an 80 percent retention rate of students in the Teacher Education Program. During the 2006–2007 academic year, there are 1,521 students enrolled in the program that leads to the Associate of Arts in Teaching Degree. The program is fully articulated with several four-year institutions in Texas.

In addition to the Teacher Education Program, HCC also offers educational preparation in an alternative certification program that is offered via continuing education. The Alternative Certification Program is a state-approved teacher certification program that prepares individuals for certification in elementary and secondary levels of teacher education. The College offers certifications in 12 areas (Bilingual Generalist, Generalist, ESL, History, Life Science, Mathematics, Physical Education, Physical Science, Science, Social Studies, Special Education, and Technology Applications). Since January 2003, the College has enrolled 398 students in the program. Of that total, 148 students have completed the Alternative Certification Program. Among the requirements for the program are a Bachelor's degree from an accredited institution of higher education, an overall grade point average of 3.0 or an advanced degree, 2.50 on Bachelor's degree, and 2.5 overall. The State Board of Educator Certification approved the Alternative Certification Program in November 2002.

The NSF has recognized the importance of community colleges to growing the numbers of qualified STEM teachers with a series of publications and conferences addressing the issue. In terms of ongoing programmatic support for community college teacher recruitment, preparation, and professional development efforts, however, I believe there is room for growth. Support for these efforts at community colleges is found on a relatively small scale across a number of current programs, including the ATE program as noted above and the Math and Science Education Partnerships. In general, the NSF approach to this issue is fairly research-oriented. This research is important, but so are the "implementation" activities aimed at growing the ranks of teachers.

For this reason, I applaud the introduction of the *"10,000 Teachers, 10,000 Minds Science and Math Scholarship Act"* (H.R. 362). In recent years, the Robert Noyce Scholarship Program has been an important NSF program in this area, which provides scholarships and stipends to juniors, seniors and current professionals intending to become STEM teachers, as well as additional programming to support their studies. Because of its design, community college involvement in the program has been limited. For this reason, I am heartened to see in H.R. 362 an intention to widen the program to the first two years of undergraduate studies. I believe that further refinement of the language in that legislation may be needed to effectively bring community colleges into the fold of this important program. I also welcome the separate authorization for the Teacher Institutes for the 21st Century. AACC looks forward to working with the community to ensure that community colleges are active partners in these efforts.

Do community colleges believe that NSF is adequately serving the science and technology education and research needs of U.S. community colleges?

I am persuaded that the National Science Foundation continues to do an excellent job in identifying specific areas for academic concentration and research funding based upon their input from partnering agencies, such as the American Association of Community Colleges, the National Academy of Science, and other agencies that provide information on the "current needs" of the Nation. As I mentioned above, the NSF has become a key source of federal support for our institutions and students and I look forward to our continued partnership. As reauthorization moves forward, I believe there is an opportunity to build upon this partnership through the suggestions made above to ensure that community colleges are fully utilized in increasing the Nation's STEM competitiveness.

Chairman Baird, Ranking Member Ehlers, Members of the Committee, I thank you for the opportunity to testify before the Research and Science Education Subcommittee today.

BIOGRAPHY FOR MARGARET F. FORD

Dr. Margaret Fincher Ford is President of the Houston Community College–Northeast, one of six colleges within the Houston Community College System. She was appointed President of the Northeast College in 1997 after a National Search conducted by the Association of Community College Trustees (ACCT).

Dr. Ford was born in Marion, Alabama, and completed her early education at Lincoln High and Robert C. Hatch High Schools. She completed her Baccalaureate and Master's Degrees in the Teaching of English at Wichita State University, her Doctoral Degree in Education at the University of Houston, and Certificates from Oxford University and Kansas State University in International Relations and Urban and Regional Planning, respectively. In 1997, she received a Certificate of Completion from the American Association of Community Colleges (AACC) for participation in the Presidents' Academy; and in July 2001, she was an invited delegate to the Oxford International Roundtable for Community College Presidents—held in Oxford, England, where she presented a paper to an international audience of community college presidents on the topic: "A Higher Education Transition Pedagogy for Marginalized Populations: Challenges, Opportunities, Benefits."

Dr. Ford has over thirty years of experience in higher education. She began her higher education career as a Professor at Wichita State University where she served for ten years. She has also been a Visiting Professor at Bethany College in Lindsborg, Kansas, a faculty member at the University of Houston and Texas Southern University, and an invited delegate to the "Germany Today" educational program. At the Houston Community College, she has served as an instructor of English and in various administrative posts leading to the presidency. She has also been a television producer and host with PBS Television Programs entitled "The Capitol Report" (broadcast Statewide) and "The Margaret Ford Show" (broadcast locally on KUHT TV). Recently she was the Plenary Session Speaker at the Consortium for Student Retention Data Exchange (CSRDE) held in Albuquerque, New Mexico, and a participant in the "Learning Matters" Podcast on Community Colleges produced by John Merrow.

Dr. Ford has written numerous articles that have been published in various scholarly journals and publications. The most recent articles include, "Factors Influencing the Matriculation and Course Completion of First Time In-College Students," published in the *Proceedings of the 2nd Annual National Symposium on Student Retention,* and "Quality of Life and Resiliency: A Focus on Student Success," published in the *Community College Journal*—a publication of the American Association of Community Colleges where Ford has also published other scholarly articles. She has co-authored several resource workbooks and one textbook. The textbook is a formulary written by Ford and published by Sage Publications in 1997. The book is entitled *High School Students Earning College Credit: A Guide to Creating Dual Credit Programs.* The focus of Ford's book is Dual Credit, which was the first text on the subject. She is also the author of other related Dual Credit publications and of the Teacher/Student Interaction Instrument, which is an assessment tool to measure the attitudes of teachers toward diverse student populations.

Dr. Ford is very active in the Houston community and serves on a number of Workforce Development Committees and Advisory Boards. She is an active participant in local Chambers of Commerce and works closely with industry advisory committees for economic and community development. She is the recipient of the 2006 Education Award presented by the L&S Academy; the 2005 Carrol Sterling

Masterson Education Award presented by the YWCA Board of Directors, and the 2004 Education Award presented by the Acres Homes Citizens' Chamber of Commerce. In March 2006, she became the recipient of the IMPACT Honoree Award in Education presented by the Women's Guild. In May 2006, she received the Education Award presented by Variety—The Children's Charity of Houston. Dr. Ford has also received the prestigious District Award of Merit presented by the Sam Houston Council of Boy Scouts of America—Antares District where she served as District Chair for several years. She is a Senior Education Advisor for the State of Texas—an honor conferred by the Office of the Governor in 1999. Recently, she served as a member of the National Academy of Science's Transportation Research Board that produced Special Report #275 on *The Workforce Challenge*. She also serves on the AACC Global Education Commission and served as a member of the Homeland Security Ad Hoc Taskforce which resulted in an AACC Report entitled *First Responders: Community Colleges on the Front Line of Security*. Dr. Ford was elected to the AACC Board in 2005 by peer community college presidents, where she serves on the Executive Committee and is the Board Liaison for the National Council on Student Development.

Dr. Margaret Fincher Ford resides in Houston, Texas.

Chairman BAIRD. Thank you, Dr. Ford. Dr. Meriles.

Mr. MERILES. Chairman Baird, Ranking Member Ehlers, and Members of the Subcommittee.

Chairman BAIRD. Dr. Meriles, make sure you have hit that mike button. I always forget myself, so——

STATEMENT OF DR. CARLOS A. MERILES, ASSISTANT PROFESSOR OF PHYSICS, THE CITY COLLEGE OF NEW YORK, CUNY

Dr. MERILES. Yes, it is probably too far. Chairman Baird, Ranking Member Ehlers, and Members of the Subcommittee, I greatly appreciate the opportunity to testify before you today.

I am an Assistant Professor of Physics at the City College of New York, where I have been since 2004. I am currently funded by the National Science Foundation through two programs, a Career Award, the signature NSF program for young investigators, and a NIRT grant, a nanotechnology-oriented interdisciplinary program that I run in partnership with three other investigators at CCNY and the University of California at Berkeley.

These programs intersect three of the issues before this committee today: first, how to nurture young scientists; second, how to catalyze novel, cutting-edge research through cross-disciplinary teams; and third, how to effectively integrate academic and industry activities.

These are complex topics, and they do not lend themselves to simplistic analysis. I hope, however, that my thoughts may constructively help you in developing wise public policy as you proceed with the National Science Foundation reauthorization bill. For young scholars, the Faculty Early Career Development Program is arguably the most important federal activity supporting scientists at the early stage of their careers. It is also one of the very few that allows the participation of individuals who, as in my case, teach at American universities but were born and raised abroad. Finally, it is a program that integrates research and education, and as such, serves as a model for other science agencies in the Americas and overseas.

Unfortunately, from my anecdotal experience with other young scientists, many of them truly outstanding, the career program appears to suffer from significant lack of resources, leading many

worthy applicants to submit proposals two or three times before they achieve success. Proposal writing is arduous and time consuming, and having to wait two or three years to land the career grant, while the tenure clock is ticking, can put an end to a promising career.

Although shortage of money is a significant problem, it is not the only one. The NSF seems to evaluate junior faculty proposals on the basis of the same traditional merit review criteria it uses for established investigators. While I believe the NSF must stress quality and the likelihood of success of the research project, I believe that the NSF career program would benefit enormously if reviewers were instructed to place greater emphasis on creativity and originality when judging proposals from junior scientists. The early career enterprise in academia is a highly nonlinear process, a minimum threshold infrastructure is required to produce the very first piece of significant data. At times, this proves a formidable task, especially in universities and colleges that do not emphasize research as strongly, or that lack an adequate human and physical infrastructure. Even in an adverse environment, young scientists are, by nature, the most prone to take risks and think in a different, perhaps more creative manner.

Therefore, I suggest that, especially for younger scientists, NSF program managers identify and nurture the most inventive ideas, even if the chances of success are not completely locked in. For extremely high risk creative proposals, NSF could consider a preliminary award of somewhat shorter duration to achieve a proof of principle. Taking into consideration that decisions on tenure are often made after only a few years, the career program should also have a more flexible chronogram, for instance, with proposals accepted two times during the year, rather than one, as is currently the case.

For young, inexperienced investigators, problems may be encountered even after they obtain initial funding. Sometimes, costs exceed those originally envisioned. Unforeseen difficulties in the progress flow, or family responsibilities intrude. The last applies, in particular, to female scientists, when a child is born, but emergencies can arise when a family member requires special care. Program managers and university administrators ought to work closely with each other to maximize the possibility of a successful outcome of the research.

Let me turn now to the interplay between scholarly research and industry application. This ought to be an important driving force in a successful model of science policy, yet university-industry partnerships are far from widespread, and junior faculty often find it difficult to initiate one, particularly in middle and small sized universities, where scholarly work has traditionally remained disconnected from industrial needs.

The NSF should invigorate the existing programs by broadening the range of opportunities. Cooperation based solely on industry cost sharing seems to me unrealistic, more so in the case of young investigators, because companies tend to be very conservative and risk-averse. The Federal Government ought to provide greater incentives through tax policies, but NSF ought to encourage other avenues of partnership, for example, short-term student industry

internships. Internships are, indeed, an important ingredient in programs such as the IGERT, but the large scale of these initiatives makes them unlikely to prosper in places other than those already having strong ties with industry.

Smaller size educational programs that emphasize academia-industry partnerships should be also considered and nurtured, especially when they are initiated and led by junior faculty. The Committee might also consider requesting the Foundation to explore the feasibility of establishing an NSF-wide mission office to serve as a liaison between industry and academia. Such an office could serve as a forum to facilitate contact between young scholars and entrepreneurs and coordinate the efforts of the various NSF divisions in areas ranging from education to instrumentation development.

Let me conclude by observing that many future scientific breakthroughs will occur across the boundaries of the traditional scientific disciplines. The Committee should encourage NSF to be ever cognizant of these interdisciplinary opportunities.

Once again, I thank you for the opportunity to testify, and I look forward to responding to any questions the Members of the Committee may have.

[The prepared statement of Dr. Meriles follows:]

PREPARED STATEMENT OF CARLOS A. MERILES

Chairman Baird, Ranking Member Ehlers and Members of the Subcommittee, I greatly appreciate the opportunity to testify before you today. I am an Assistant Professor of Physics at The City College of New York (CCNY), where I have been since 2004. I am currently funded by the National Science Foundation through two programs: a CAREER award, the signature NSF program for young investigators, and a NIRT grant, a nanotechnology-oriented, interdisciplinary program that I run in partnership with three other investigators at CCNY and the University of California at Berkeley.

These programs intersect three of the issues before this committee today: first, how to nurture young scientists; second, how to catalyze novel, cutting-edge research through cross-disciplinary teams and third, how to effectively integrate academic and industry activities. These are complex topics, and they do not lend themselves to simplistic analysis. I hope, however, that my thoughts may constructively help you in developing wise public policy as you proceed with the National Science Foundation Reauthorization Bill.

Before I begin, let me say a word about my personal history. I was born in Argentina and received my undergraduate and graduate degrees in my native country. I came to the United States in 2000 as a Berkeley "postdoc" before joining the faculty at CCNY in 2004. I left my homeland because my passion for science led me to seek the best opportunities for a young researcher. I believed and still believe that those opportunities are greatest in the United States, although complacency and federal budgetary strictures could place that status at risk.

For young scholars, the Faculty Early Career Development (CAREER) Program is arguably the most important federal activity supporting scientists at the early stage of their careers. It is also one of the very few that allows the participation of individuals who, as in my case, teach at American universities but were born and raised abroad. Finally, it is a program that integrates research and education and, as such, serves as a model for other science agencies in the Americas and overseas.

Unfortunately, from my anecdotal experience with other young scientists, many of them truly outstanding, the CAREER program appears to suffers from significant lack of resources, leading many worthy applicants to submit proposals two or three times before they achieve success. Proposal writing is arduous and time-consuming, and having to wait two or three years to land a CAREER grant, while the tenure clock is ticking, can put an end to a promising career.

Although shortage of money is a significant problem, it is not the only one. The NSF seems to evaluate junior faculty proposals on the basis of the same traditional merit review criteria it uses for established investigators. While I believe the NSF must stress quality and the likelihood of success of a research project, I believe that

the NSF CAREER program would benefit enormously if reviewers were instructed to place greater emphasis on creativity and originality when judging proposals from junior scientists.

The early career enterprise in academia is a highly non-linear process. A minimum, threshold infrastructure is required to produce the very first piece of significant data. At times this proves a formidable task, especially in universities and colleges that do not emphasize research as strongly or that lack an adequate human and physical infrastructure. Even in an adverse environment young scientists are, by nature, the most prone to take risks and think in a different, perhaps more creative manner. Therefore, I suggest that, especially for younger scientists, NSF program managers identify and nurture the most inventive ideas, even if the chances of success are not completely locked in.

For extremely high-risk creative proposals, NSF could consider a preliminary award of somewhat shorter duration to achieve a proof of principle. Taking into consideration that decisions on tenure are often made after only five years, the CAREER program should also have a more flexible chronogram, for instance, with proposals accepted two times during the year, rather than one, as is currently the case.

For young, inexperienced investigators, problems may be encountered even after they obtain initial funding. Sometimes costs exceed those originally envisioned, unforeseen difficulties render progress slower or family responsibilities require attention. Unfortunately, the last applies in particular to female scientists when a child is born. But emergencies can also arise when any family member requires special care. Program managers and university administrators ought to work closely with each other to maximize the possibility of a successful outcome of the research.

Let me now turn to the interplay between scholarly research and industrial application. This ought to be a potent driving force in a successful model of science policy. Yet, university-industry partnerships are far from widespread, and junior faculty often find it difficult to initiate one, particularly at middle and small-size universities where scholarly work has traditionally remained disconnected from industrial needs. The NSF should invigorate existing programs by broadening the range of opportunities.

Cooperation based solely on industry cost sharing seems unrealistic to me—more so in the case of young investigators—because companies tend to be very conservative and risk averse. The Federal Government ought to provide greater incentives by amending the R&D tax policy to grant a company, at the very least, the same credit for partnering with a university as it now receives for research it conducts on its own.

But NSF ought to encourage other avenues of partnerships; for example, short-term student industrial internships. Internships are indeed an important ingredient in programs such as the Integrative Graduate Education and Research Traineeship (IGERT) program, but the large scale of these initiatives makes them unlikely to prosper in places other than those already having strong ties with industry. Smaller-size educational programs that emphasize academia-industry partnerships should be also considered and nurtured, especially when they are initiated and led by junior faculty. The Committee might also consider requesting the Foundation to explore the feasibility of establishing an NSF-wide mission office to serve as a liaison between industry and academia. Such an office could serve as a forum to facilitate contact between (young) scholars and entrepreneurs and coordinate the efforts of the various NSF divisions in areas ranging from education to instrumentation development.

Let me conclude by observing that many future scientific breakthroughs will occur across the boundaries of the traditional scientific disciplines. The Committee should encourage NSF to be ever cognizant of these interdisciplinary opportunities and to ensure that interdisciplinary proposals do not fall between the cracks of NSF disciplinary offices.

Once again, I thank you for the opportunity to testify, and I look forward to responding to any questions the Members of the Committee may have.

BIOGRAPHY FOR CARLOS A. MERILES

Carlos Meriles is an Assistant Professor of Physics at the City College of New York–CUNY. He joined CCNY in 2004 after working as a postdoctoral associate in the laboratory of Prof. Alexander Pines at the University of California, Berkeley. He carried out his undergraduate and graduate studies at the Facultad de Matematica, Astronomia y Fisica (FaMAF–UNC), one of the leading scientific institutions in his native Argentina.

Professor Meriles obtained his Ph.D. with honors in 2000. In 2006 he received an NSF–CAREER award and soon after a Wegman Fellowship from the Wegman Foun-

dation in New York City. He has been the recipient of a number of scholarships, among them the prestigious CONICET postdoctoral fellowship for studies abroad. During his graduate studies he received the Young Investigator award from the Universidad Nacional de Cordoba (Argentina). His research focuses on the development of new methods for nuclear magnetic resonance imaging and spectroscopy and on the application of these methods to materials science.

Chairman BAIRD. Thank you, Dr. Meriles. Dr. Welser.

STATEMENT OF DR. JEFFREY J. WELSER, DIRECTOR OF THE NANOELECTRONICS RESEARCH INITIATIVE, SEMICONDUCTOR RESEARCH CORPORATION

Dr. WELSER. Good afternoon. My name is Jeff Welser, and I am on assignment from the IBM Corporation to head the Nanoelectronics Research Initiative, or NRI. I appreciate the opportunity to testify today on behalf of the NRI, the IBM Corporation, the Semiconductor Industry Association, and the Semiconductor Research Corporation.

Let me say at the outset that we are all strong supporters of the NSF. We endorse the significant funding increases proposed in the Fiscal Year 2008 budget, the House Democrats Innovation Agenda, and the American Competitiveness Initiative. The Semiconductor Industry Association has also endorsed H.R. 362 and 363, the Ten Thousand Teachers, Ten Million Minds, and Sowing the Seeds Innovation bills.

My written testimony includes information about how the semiconductor research is not only one of the main drivers of the U.S. economy today, but also saves the government itself significant money. I also cover in detail our commitment and thoughts on education, and increasing the pipeline of students trained in the STEM disciplines so crucial to our industry.

So, in the next five minutes, I would like to focus my remarks on three of the questions submitted by the Committee, related to why the semiconductor industry invests in basic research at universities, the relationship between the NRI and NSF, and what advice we have regarding industry-university partnerships in general.

Before answering these questions, I should provide a bit of background on the NRI and our quest for a new computing switch. Computer chips today basically consist of a huge number of interconnected on-off switches called transistors. The unprecedented growth in computing power over the past 30 years, and the information technology economy that it has driven, has been mostly due to our ability to shrink these transistors over time, so that today, billions of these inexpensive ubiquitous switches can be put on a single chip, providing your laptops, cell phones, and Blackberries with power.

We expect to continue to drive down the cost of computing through this continued scaling and other innovations, for the next 12 to 15 years, at which point, we will reach the physical and power limits of this switch technology. If we are to continue to advance information technology beyond that point, we will need a new nanoelectronics switch. To take on this task, the SRA launched the Nanoelectronics Research Initiative, and its mission is to fund research to discover a new switch by 2020.

Which brings me to the Committee's first question: why does the semiconductor industry invest in university research? First, we

want to help generate basic science research that is relevant to industry needs. The close collaboration and technology transfer mechanisms that we have developed over time also help industry quickly commercialize that research as it becomes available.

Second, the graduate students that we support are the next generation workforce for the industry. Companies that work closely with universities get to know the students, and the students get to know the companies, and they also can benefit from the valuable insights from industry advisors on their own research.

Even before the NRI, the SRC has been funding universities for 25 years, supporting over 5,000 students, and producing over 30,000 technical documents crucial to sustaining our semiconductor roadmap and the IT economy which depends on it. This has never been more crucial than now, as we are faced with the challenge of finding a new switch.

Which brings me to your second question: why are the industry and NSF working together? The SRC and NSF have a long, successful history of interaction, including joint workshops, funding to NSF university centers, giving industry input and lists of expert reviewers for potential consideration in NSF program solicitations. Now, in searching for a new switch, the NRI pulls together semiconductor companies, State governments, and the NSF to support research at 25 universities in 13 states, including major centers at California, Texas, and New York.

NSF was a natural partner, given the basic research needed in a wide range of scientific and engineering disciplines. Simply put, both the NSF and industry recognized that the country whose companies are first to market with a new logic switch will likely lead in the nanoelectronics era, the same way the United States has led for the last half-century in the microelectronics era.

U.S. leadership in microelectronics has had tremendous benefits for the U.S., to our companies, to our national security, as well as to the advancement of science in general. Indeed, the sequencing of the human genome is as much a computing success as it is a biological success.

The Committee's third question, asking for our thoughts on industry and university partnerships in general. First, we continue to encourage multi-disciplinary research, as it is one of the unique strengths of the NSF, that makes it attractive to industry. To this end, we highly encourage the NSF to continue to support centers and multi-year programs such as the Nanoscale Science and Engineering Centers, or NSECs, and group awards, such as the Nanoscale Interdisciplinary Research Teams, or NIRTS, and Nanoscale Exploratory Research Awards, the NER Awards. The NRI has already co-invested in projects at these centers, and they are very effective vehicles for pursuing diverse research topics that require expertise from different fields.

Second, we encourage the NSF to pursue these multi-disciplinary research in other industries as well, beyond nanoelectronics, particularly in the emerging field of services science. Services today makes up 80 percent of the U.S. economy, and the ability to integrate scientific, management, engineering, and other skills is a talent needed throughout the services sector. NSF's budget in this

area should be increased, and universities should be encouraged to establish research and curricula expanding in this nascent field.

Finally, we suggest the Committee consider authorizing NSF to participate in as well as with industrial consortia. As an example, DARPA has participated in semiconductor consortium through the so-called other authorities, other agreements authority, which moves away from the grantor-grantee role, or contractor-supplier role, that is appropriate for engaging with universities directly, but not as well suited if an agency is to participate directly in a consortium. Under this program, the industry and government money is pooled, decisions to fund universities programs are approved through a merit-based process, overseen by a council that includes both industry and the Defense Department in that case.

I would emphasize that we find the partnership we have with the NSF already very successful, and intend to continue to interact closely, but providing NSF with this type of flexibility could open the door to greater collaboration among the industry, NSF, and universities.

In closing, I would like to point out that the magnitude of the effort we face in finding a new switch is equivalent to what was done in the '40s and '50s, as we searched for an alternative to vacuum tubes. Then, as now, success only came from the combination of the best science coming out of the universities, the mission focus of the industrial labs, and significant funding from the government. This collaborative interaction enabled both the scientific breakdowns and reduction to practical implementation that was necessary for success.

To this end, increasing research funding at NSF, and expanding NSF's collaboration with the industry is absolutely essential if America is to lead in the coming nanoelectronics era.

Thank you, and I look forward to answering any questions.

[The prepared statement of Dr. Welser follows:]

PREPARED STATEMENT OF JEFFREY J. WELSER

Good afternoon. My name is Jeffrey Welser and I am on assignment from the IBM Corporation to serve as the Director of the Nanoelectronics Research Initiative (NRI). I am testifying today on behalf of the NRI; the IBM Corporation; the Semiconductor Industry Association; and the Semiconductor Research Corporation.

The Nanoelectronics Research Initiative (NRI) is a research consortium that supports university basic research in novel computing devices, to enable the semiconductor industry to continue technology advances beyond the limits of the CMOS[1] technology that we have been using for the past four to five decades. The NRI leverages industry, university, and both U.S. State and Federal Government funds, to support research at universities that will establish the U.S. as the world leader in the nanoelectronics revolution. Fundamental breakthroughs in physical sciences and engineering resulting from NRI leadership will ensure that the U.S. remains a world leader in high-technology.

At IBM, we strive to lead in the creation, development and manufacture of the industry's most advanced information technologies, including computer systems, software, networking systems, storage devices and microelectronics. We translate these advanced technologies into value for our customers through our professional solutions and services businesses worldwide, which account for nearly three quarters of our annual revenues.

The Semiconductor Industry Association (SIA) has represented America's semiconductor industry since 1977. The U.S. semiconductor industry has 46 percent of the $248 billion world semiconductor market. The semiconductor industry employs

[1] Complementary Metal Oxide Semiconductor

232,000 people across the U.S., directly contributes $60 billion to U.S. GDP and is one of America's largest export sectors.

The Semiconductor Research Corporation is a world class university research management consortium that seeks to solve the technical challenges facing the semiconductor industry and to develop technical talent for its member companies. SRC manages several semiconductor research programs including the NRI. Since its founding 25 years ago, the SRC has managed through its core program $854 million in research funds supporting 5,586 students and 1,244 faculty at 218 universities resulting in 31,865 technical documents, and 270 patents.

Executive Summary

- The semiconductor industry strongly supports doubling the NSF research budget as part of our complete set of competitiveness recommendations. These recommendations include increased availability of green cards and H–1Bs visas through immigration reform; increased numbers of science, technology, engineering and math graduates and improved K–12, undergraduate and graduate math/science education; enactment of a permanent and enhanced R&D credit; and increased awareness of the impact of foreign tax incentives.
- The National Science Foundation's (NSF) support for research, development, and math and science education is a vital component of America's science and technology enterprise. NSF's activities under gird the Nation's innovation capacity, promote long-term economic growth, and enhance international competitiveness of the United States.
- The semiconductor industry supports significant funding increases for NSF as proposed in the House Democrats' Innovation Agenda and the President's American Competitiveness Initiative. The Semiconductor Industry Association (SIA) also has endorsed H.R. 363, the *Sowing the Seeds Through Science and Engineering Research Act,* that was reported out of the full Science and Technology Committee on March 8, 2007.
- SIA believes strongly that NSF's education programs need to be expanded and monetarily supported, and SIA also has endorsed H.R. 362, the *10,000 Teachers, 10 Million Minds Science and Math Scholarship Act.* Continued robust NSF activities in the areas highlighted in the bill are vital for the future competitiveness of the United States.
- Semiconductor technology advances have been credited with driving the increased productivity that the U.S. economy has enjoyed since the mid-1990's. The government sector has also benefited from faster and cheaper computing—receiving $152 billion of "free" computing cumulatively as a result of technology improvements and resulting price declines in the last ten years.
- One way in which NSF contributes directly to U.S. competitiveness is by funding basic research in nanotechnology jointly with industry. As we approach the fundamental limits of the current technology which has driven the high tech industry, the country whose companies are first to market in the subsequent technology transition will likely lead the coming nanoelectronics era the way the U.S. has led for half a century in microelectronics.
- The Nanoelectronics Research Initiative (NRI) leverages industry, university and government resources (both State and Federal) to fund university research that will keep America at the forefront of the nanoelectronics revolution. NRI currently works largely through three regional university centers headquartered in California, Texas, and New York.
- The partnership between NSF and industry in NRI results in a more productive research program because it brings together the technical expertise of industrial research managers and university scientists. Moreover, by jointly funding research with industry, NSF can focus basic research efforts on scientific questions that have maximum potential economic impact. It is a classic win-win situation.
- To strengthen these partnerships and nanoelectronics research overall, we recommend giving NSF the flexibility to participate in industry consortia, funding basic science research at universities. We also recommend NSF continue to support centers, such as the Nanoscale Science and Engineering Centers (NSECs), and group awards, such as the Nanoscale Interdisciplinary Research Teams (NIRTs) and Nanoscale Exploratory Research (NER) awards, as very effective vehicles for pursuing research topics of national interest.

NSF funding should be significantly increased

Let me state at the outset that the semiconductor industry strongly supports doubling the NSF research budget, as envisioned in the House Democratic Innovation Agenda, and the 2006 American Competitiveness Initiative. The industry's support for increased research funding is part of our complete set of competitiveness recommendations which include increased availability of green cards and H–1Bs visas through immigration reform; increased numbers of science, technology, engineering and math graduates and improved K–12, undergraduate and graduate math/science education; enactment of a permanent and enhanced R&D credit; and increased awareness of the impact of foreign tax incentives.

Federal funding of basic research, and in particular, funding in nanoelectronics research, is vital to America's future economic growth and global competitiveness. Simply put, as we approach the fundamental limits of the current technology which has driven the high tech industry, the country whose companies are first to market in the subsequent technology transition will likely lead the coming nanoelectronics era the way the U.S. has led for half a century in microelectronics, and NSF can play a critical role in ensuring that America earns this leadership position.

Today I would like to share our thoughts on the critical need to continue semiconductor technology advances, the Nanoelectronics Research Initiative (NRI) as an example of NSF collaboration with industry on fundamental university research, the importance of research in services as example of another industry where collaboration with NSF is highly valued, and the vital role NSF plays in promoting math and science education.

To continue semiconductor technology advances, we must find a new switch

Semiconductors are the enabling technology for computers, communications, and other electronics products that in turn have enabled everything from Internet commerce to sequencing the human genome.

Better, faster, and cheaper chips are driving increased productivity and creating more jobs throughout the economy. For over three decades the industry has followed Moore's Law, which states that the number of transistors on a chip doubles about every eighteen months. The transistor is the basic building block within the semiconductor chip and can be thought of as an electronic switch or as a device to retain one bit (a one or a zero) in memory. The transistor is composed of a series of precisely etched and deposited layers of materials, and with as many as two billion transistors integrated on a single silicon chip, modern computer chips are some of the most complex products manufactured on the planet.

Today the cost of making one million transistors is one penny.

The phenomenal advances in technology may slow drastically as semiconductor technologists have concluded that we will soon be reaching the fundamental limits of CMOS technology, the process that has been the basis of innovation for the semiconductor industry for the past 30 years. By introducing new materials into the basic CMOS structure and devising new CMOS structures and interconnects, further improvements in CMOS can continue for the next ten to fifteen years, at which time CMOS begins to reach its physical (layers only a few atoms thick) and power dissipation limits. For the U.S. economy to benefit from continued information technology productivity improvements, there will need to be a "new logic switch" to replace the current CMOS-based transistor.

There are a number of candidates for the new switch, including devices based on spintronics (changing a particle's spin) and molecular electronics (changing a molecule's shape). Scientists must address many challenges in many different basic research fields (chemistry, physics, engineering) in the search for the new switch, including measuring the dimensions, shapes, and electrical characteristics of individual molecules; manipulating and measuring the spin of individual electrons; fabricating whole new classes of materials with unique electronic properties, and then characterizing their fundamental physical behavior and their long-term reliability; inducing novel chemical compounds to self-assemble into the precise structures needed by the new devices and architectures; and finally finding ways to interconnect the devices and integrate them into our technology infrastructure in a cost-effective manner that will enable us to continue the historical cost and performance trends for information technology.

Industry Research Consortia

Much of the early progress of the semiconductor industry derived from technology developed in large, corporate research and development facilities, such as Bell Laboratories. In the early 1980s, industry leaders, such as Bob Noyce of Intel and Erich Bloch of IBM, perceived a decline in the output of such corporate research facilities

and a need to bolster underlying technology as a means to keep the U.S. semiconductor industry globally-competitive.

To this end, the SIA's Board of Directors established the Semiconductor Research Corporation (SRC), a non-profit consortium of companies representative of the full spectrum of the semiconductor industry. Erich Bloch of IBM was the first Chairman of the SRC and later became a Director of the National Science Foundation.

In its current form, the SRC provides research management and administrative services on behalf of the companies that participate in three semiconductor research consortia: the Global Research Collaboration (GRC), the Focus Center Research Program (FCRP) and the Nanoelectronics Research Initiative (NRI).

Global Research Collaboration Program

The Global Research Collaboration program is the core research program of the SRC. Its purpose is to: (i) sponsor university research in order to expand the number of students and the capability of universities engaged in semiconductor-related research; and (ii) generate basic research results that are relevant and available to the entire industry.

The approach of the GRC is to fund, on a competitive basis, project proposals from individual university faculty, assisted by students, in targeted areas of semiconductor research. Since 1982, the GRC has funded approximately $850 million of university research projects.

Focus Center Research Program

In 1997, the Defense Department and the U.S. semiconductor industry launched the FCRP—a jointly funded program to support a new type of university research in semiconductor technology. By focusing on mid- to long-term technology challenges of greatest interest to the Defense Department and the semiconductor industry, the FCRP seeks to marshal university efforts into integrated and sustained centers of research.

Oversight of the FCRP is through a governing council which includes industry participants and officials from the Defense Advanced Research Projects Agency (DARPA). It currently operates on approximately $20 million in Defense Department annual funding managed through DARPA, coupled with $20 million of industry funds. FCRP contracts directly with the lead university at each center conducting the research.

Current FCRP funding supports select research projects at five university clusters involving 38 universities, 200 research professors and 400 graduate students. The five university centers receive three-year contracts as a result of a joint Defense Department-industry solicitation and award for breakthrough research proposals.

Nanoelectronics Research Initiative

As the laws of physics narrow the potential for the kind of scaling that has historically characterized the semiconductor industry, attention has turned to the development of a new logic switch as a means to continue the progress depicted by Moore's Law. To take on the daunting task of identifying and demonstrating the commercial feasibility of a new logic switch, the SIA launched, under the SRC umbrella, the Nanoelectronics Research Initiative.

The NRI is an industry-university-government partnership to find a new switch

The NRI pulls together semiconductor companies, 25 universities in 13 states, State governments, and the NSF. The industry contribution through the NRI is about $5 million per year. This is in addition to about $60 million that the semiconductor industry is investing in universities through research consortia, with millions more invested directly by individual companies.

The research activity is organized within three NRI university centers that were established in 2006, plus NRI and NSF supplemental co-funding of nanoelectronics projects at 10 existing NSF university centers. The three NRI university centers are virtual centers, grouped largely by geography, and while all of the centers are working on research aimed at finding a new logic switch, the focus of the programs at each center has its own specific character:

The Western Institute of Nanoelectronics (WIN) is headquartered at the UCLA and includes the UC–Berkeley, UC–Santa Barbara, and Stanford University. WIN focuses solely on spintronics and related phenomena, extending from material, devices, and device-device interaction all the way to circuits and architectures. In addition to its NRI funding, this center receives additional direct support from Intel and the California's UC Discovery program.

The Institute for Nanoelectronics Discovery and Exploration (INDEX) is headquartered at the State University of New York–Albany (SUNY–Albany) and includes the Georgia Institute of Technology, Harvard University, the Massachusetts Institute of Technology, Purdue University, Rensselaer Polytechnic Institute and Yale University. INDEX focuses on the development of nanomaterial systems; atomic-scale fabrication technologies; predictive modeling protocols for devices, sub-systems and systems; power dissipation management designs; and realistic architectural integration schemes for realizing novel magnetic and molecular quantum devices. INDEX also receives additional direct support from IBM and New York State.

The South West Academy for Nanoelectronics (SWAN) is headquartered at the University of Texas–Austin and includes UT–Dallas, Texas A&M, Rice, Notre Dame, Arizona State and the University of Maryland. SWAN focuses on a variety of new devices, including spin-based switches, nanowires, nano-magnets, and devices which use electron wave or phase interference. In addition, work is being done on modeling; novel interconnects, such as plasmonics; and nano-metrology techniques. In addition to its NRI funding, SWAN receives additional support from Texas Instruments and the Texas Emerging Technology Fund.

In addition to these centers, NRI and NSF co-fund supplemental grants for NRI-related research at existing NSF nanoscience centers (Nanoscale Science and Engineering Centers (NSECs), Materials Research Science and Engineering Centers (MRSECs), and the Network for Computational Nanotechnology (NCN)). We are currently supporting 12 projects at 10 NSF centers, which range from advanced computer simulation of spin-based devices to measurements of non-equilibrium coherent transport in single-layer graphene sheets to directed self-assembly of quantum dot and wire structures for novel devices. The goal in making this joint investment with NSF is not only to complement the work going on in the NRI centers, but also to leverage the work going in the NSF centers, with the NRI program gaining from the knowledge being created in the NSF center as a whole and the NSF centers gaining from the industry involvement through NRI. We see the NSF centers as a very valuable resource for pursuing nanoelectronics research requiring the integration of multiple science and engineering disciplines, and strongly support NSF's continued investment in the centers and multi-year, group awards.

Collaborative research is a classic win-win situation

The U.S. semiconductor industry is investing in basic university research because it recognizes that the country whose companies are first to market will likely lead the coming nanoelectronics era the way the U.S. has led for half a century in microelectronics. Investment in universities not only results in the science and engineering breakthroughs needed to continue the rapid progress in semiconductor technology, but also increases the number of students with advanced degrees in the appropriate areas to work in the industry, increasing our competitiveness in the long-term.

Industry recognizes that the tight collaboration of industry-university-government involvement will be crucial to the success of this large research endeavor. Due to the magnitude of the scientific challenges ahead, and the large diversity of scientific disciplines required, NSF involvement in the effort to find a new switch is absolutely critical. The House Appropriations Committee recognized this fact when it singled out the NSF's work with the NRI as well as its Silicon Nanoelectronics and Beyond program in its committee report and encouraged such work to be continued.[2]

The partnership between universities, industry, and the National Science Foundation in NRI results in a more productive research program because it brings together the technical expertise of industrial research managers and university scientists. In creating the NRI university centers, the NRI's Technical Program Group (TPG), which has members from all NRI member companies, released an open call for proposals to all U.S. universities, to identify the most promising technical ideas to pursue. From these proposals, the three university centers were created, and the technical project plans are continually managed and evaluated by a joint team of professors and the TPG. In addition, industry researchers work on-site at some of the universities, to further insure a close, on-going connection between academia and industry.

[2] "The Committee commends NSF for its Silicon Nanoelectronics and Beyond program and its partnership with the Nanoelectronics Research Initiative, which involves the sponsorship of research in the areas of information' technology and electronics. The Committee encourages NSF to continue its support for such research in Fiscal year 2007." House Report 109–118—Science, State, Justice, Commerce, And Related Agencies Appropriations Bill, Fiscal Year 2006.

The NRI has also partnered with the NSF to fund work at existing NSF centers. Again the proposals are chosen from an open call to the NSF centers, with technical review by both the NSF and the NRI TPG, and the NRI stays closely linked to the work through industrial liaison teams assigned to interact with each specific project.

In addition to the direct co-funding of research at the NSF centers, the NRI has welcomed input from the government on our overall program, and would like to see these partnerships increase going forward. NSF, DARPA, and NIST already attend the NRI's Governing Council meetings which provide executive oversight to the program, and we would like to expand these partnerships in the future to allow more joint funding and technical management of the NRI work at the university centers.

As the research begins to come to fruition, prior industry involvement will facilitate technology transfer. Rapid commercialization of academic research is in the interests of universities and government funding agencies as well as industry, as it directly contribute to American competitiveness. The NRI is building on 25 years of experience by its parent, the SRC, in managing university research, in partnership with industry and the government.

Salient Features of Semiconductor Research Consortia

The GRC, FCRP and NRI have proven themselves to be highly durable and successful models for engaging universities in research. These consortia's relationship to universities is quite standard: it is generally defined by sponsored research contracts or, in some cases, grants. What is unique is the structure of the consortia themselves. These structures call for a sharing of effort and risk, benefits and costs. They have a number of salient features:

- Consortia provide multi-year support for research, faculty and students; industry participants must make a two- to three-year financial commitment and shoulder the risks inherent in such a commitment.
- Research areas are derived from the International Technology Roadmap for Semiconductors (ITRS) and have wide potential applications from personal consumer, defense, telecommunications and computing applications.
- Research is generic in nature, long-term in content and pre-competitive for industry.
- Intellectual property (IP) derived from research is available to participants on an equal, non-exclusive basis.
- Participants proceed as partners and in accordance with consensus, with no single participant able to dominate.

The combination of these features results in a consortium structure that enables participants to contribute to a broad research agenda, leverage their funding and extract what they can use. In contrast to the colloquial meaning of the term "partnership" as any form of joint activity, the consortia structures establish a partnership through a coming together of participants to share equally or proportionately in a common activity.

Overlap of Semiconductor Research Consortia with NSF's Mission

At the same time, the semiconductor industry's consortia operate in a manner that is wholly compatible with and complementary to the NSF mission.

- Both provide substantial support to university faculty and students.
- Both proceed in response to university proposals focused on basic scientific research.
- Both distribute funds based on merit review and competition.
- Both allow universities to manage and conduct the research themselves; neither industry consortia nor NSF undertake research.
- Both are dedicated to seeing the research put to use.

There are, of course, some significant differences between the approach of semiconductor industry consortia and NSF. Consortia research has been more focused and targeted to industry needs. Consortia bring more industry input and perspective to both the solicitation and award of university research proposals. Finally, because of industry involvement, the path to commercialization is more direct and widespread for universities dealing with semiconductor industry consortia.

Yet, none of these differences conflict with the primary NSF mission. On the contrary, they provide additional means that NSF could exploit and leverage in pursuing its mission.

Cooperation of Semiconductor Research Consortia with NSF

Over the years, semiconductor industry consortia have utilized three primary avenues of cooperation with NSF. First, the consortia have funded a few individual university centers such as the NSF/SRC Engineering Research Center for Environmentally Benign Semiconductor Manufacturing at the University of Arizona. The centers were solicited and awarded separately by SRC and NSF, but were based on a single statement of work and coordinated oversight.

Second, the SRC has entered into a Memorandum of Understanding (MOU) with NSF which provides for specific and voluntary interaction between industry and NSF in nanotechnology. The principal elements of the agreement are:

- SRC is to provide input to NSF for possible use in certain NSF solicitations.
- SRC is to provide a contact list of suggested industry expert reviewers who agree to serve on proposal selection panels if requested to do so by NSF Program Managers.
- SRC agrees to review the selected awards, maintain contact with recipients and offer the opportunity for voluntary participation in the SRC technology transfer processes.

To date, over $20 million in annual research conducted under the auspices of the NSF program has been subject to SRC involvement along the lines outlined above.

Third, as mentioned above, NRI has coordinated with NSF Nanotechnology Centers on supplemental solicitations. Industry has endorsed certain university proposals and made charitable contributions in support of NSF supplemental grants.

The three means of active cooperation between NSF and semiconductor industry consortia have been productive and well-received by universities. However, the cooperation has been largely informal, with NSF and industry consortia proceeding separately in accordance with their own rules and procedures.

Building on the NSF-industry NRI partnership

As is clear from the discussion above, the semiconductor industry has a long history of working with the NSF and other government agencies to support basic research and has built strong and effective partnerships. As the House Science Committee undertakes the reauthorization of the NSF, it should consider how it might provide NSF with more flexibility to work with industry in support of university research, and in particular, areas of multi-disciplinary research.

By participating in these consortia, NSF could exploit a new research avenue to enhance the value of its efforts. But maximizing the value of the consortia structure implies more than merely issuing grants or cooperative agreements. It requires NSF to join in the consortia. NSF's participation can improve the operation of the consortia and increase the value of the research results coming out of universities. By becoming a participant in NRI, for example, NSF would gain a new and powerful dimension for its work in nanoelectronics.

For it to participate fully with semiconductor industry consortia, however, NSF needs more flexibility and scope for innovation than its enabling legislation currently allows. While a grantor-grantee role or a contractor-supplier role are appropriate for engaging universities, they are not well-suited to engage with industry consortia, at least if NSF seeks to participate directly with these consortia. As a participant in semiconductor industry consortia, NSF would have an equal status and would be able to share the risks, costs and benefits of the research, like any other participant.

In order for NSF to fully engage with consortia that sponsor university research, new authority would be most helpful. DARPA, for example, has participated in the Focus Center Research Program through the so-called "other agreements" authority (10 USC 2371), which dispenses with many of the contractual requirements and overhead of the Federal Procurement Regulations. In FCRP, industry and government money is pooled, and decisions to fund university programs are approved through a merit-based process by a governing council that includes both industry and Defense Department representatives. Providing NSF access to this authority or similar authority could open the door to greater collaboration among industry, NSF and universities. This could leverage the funds going to universities, orient university research in more productive directions and enhance the prospects for commercialization of research results.

In short, NSF could benefit from statutory authority to expand beyond its current charter, with tools to enable participation in industry consortia, giving NSF the maximum flexibility to determine the most appropriate way to achieve the research objectives.

Increases in NSF nanoelectronics research funding have tremendous public benefits

Given the importance of maintaining technology leadership, the semiconductor industry supports increased research funding at the NSF, particularly in the area of nanoelectronics. The Administration's budget proposes $390 million for nanotechnology for 2008, a 4.6 percent increase over the $373 million for 2007. This is $86 million below the $476 million authorized for nanotechnology at NSF under the 21st Century Nanotechnology Research and Development Act passed in 2003, and should be increased.

Research investments to continue Moore's Law have immense benefits to the U.S. economy. Harvard economist Dale Jorgenson has noted, "The economics of Information Technology begins with the precipitous and continuing fall in semiconductor prices." Professor Jorgenson attributed the rapid adoption of IT in the U.S. for driving substantial economic growth in the U.S. gross domestic product since 1995, concluding, "Since 1995, Information Technology industries have accounted for 25 percent of overall economic growth, while making up only three percent of the GDP. As a group, these industries contribute more to economy-wide productivity growth than all other industries combined."[3]

To see the impact of the productivity gains on a single sector, it is instructive to consider the benefits the government (federal, State, and local) receives as a consumer of semiconductors. The Department of Commerce's Bureau of Economic Analysis has data indicating that the government sector of the economy purchased $6.8 billion of computers in 2005, but that they would have had to spend $34 billion for that same amount of computing power if they had to pay 1997 prices. The cumulative benefit from technology improvements and resulting price declines from 1997 to 2006 is $152 billion of "free" computing. In this tight budget year, it is important to remember that the federal investments made to support basic research are not only beneficial to the overall U.S. economy, but they also allow the government itself to do more with less as a result of falling computing costs.

Increased funding needed for services-related education programs and multi-disciplinary research

Another critical area where the National Science Foundation is leading among federal agencies is in its support for multi-disciplinary research and education in the emerging field of services science. Importantly, Chairman Baird and Ranking Member Ehlers referenced this NSF role in their remarks at the March 20 Subcommittee hearing on NSF's reauthorization.

Services make up about 80 percent of the U.S. economy, while employing approximately the same percentage of the U.S. labor force. As a country, we need to invest in the skills needed for 21st century jobs—jobs that almost certainly will be dominated by the services market. High-value services jobs require skills, beyond simple programming or systems administration. They require the ability to integrate scientific, management, engineering and other disciplines like law, economics or operations research with the people aspect of business. This talent is needed not only by the technology sector but also by every sector employing and utilizing services, including banking, health care, retail, education, government and manufacturing. In short, more skilled professionals are needed to design and implement modern service architectures that drive productivity and create new value for all types of clients, whether they are public or private sector.

The National Science Foundation is blazing new ground in this area by partnering with industry and U.S. universities to support services science research and curricula development at the undergraduate and graduate levels. This important but little-known work within the Engineering and the Education and Human Resource directorates supports the high value-added, service-sector jobs that will differentiate the U.S. economy from those of our competitors around the world. Increasing NSF's overall budget for research and education supports the nascent but incredibly important work they are doing in this field—research and curricula development that to our knowledge is not being done by any other federal agency. Establishing the academic discipline of services science will help keep the U.S. workforce competitive and prepared to lead in a rapidly evolving global economy.

NSF education programs need to be increased

A number of studies have documented the Nation's crisis in math and science education. For example, the National Academies' *"Rising Above the Gathering Storm"* report stated, "Fewer than one-third of U.S. fourth grade and eighth grade

[3] Dale W. Jorgenson, "Moore's Law and the Emergence of the New Economy" in "2020 is Closer than You Think," 2005 SIA annual report.

students performed at or above a level called "proficient" in mathematics; "proficiency" was considered the ability to exhibit competence with challenging subject matter" and recommended that the Nation "increase America's talent pool by vastly improving K–12 science and mathematics education" through steps including "annually recruiting 10,000 science and mathematics teachers by awarding four-year scholarships and thereby educating 10 million minds, and strengthen the skills of 250,000 teachers through training and education programs at summer institutes and other programs.[4]

The NSF has an important role to play in expanding the talent pipeline by supporting programs and adequate appropriations to improve science, technology, engineering and mathematics (STEM) education and attract students to these disciplines at the K–12, undergraduate, and graduate levels. For example, the additional funding for the Robert Noyce Scholarship program, named after the co-inventor of the integrated circuit, provides scholarships for undergraduates majoring in STEM disciplines in return for a commitment to teach K–12 math or science. Other NSF education programs include the Math and Science Education Partnership program to prepare undergraduates for K–12 math and science teaching, and the STEM Talent Expansion Program (STEP), which awards competitive grants to institutions of higher education to boost the number of undergraduate majors in STEM disciplines. The semiconductor industry fully supports Chairman Gordon's *"10,000 Teachers, 10 Million Minds" Science and Math Scholarship Act* (H.R. 362) that increases the authorizations for many of these programs.

Another important NSF program is the Advanced Technology Education program which helps community colleges with workforce development. The ATE program was instrumental in establishing the Maricopa Advanced Technology Education Center, an organization that helps community colleges around the country train technicians to work in semiconductor factories. Community colleges are also an important source of transfer students to four year colleges and universities, and thus should have a key role in any strategy to increase the Nation's engineering talent.[5] We would encourage the House Science Committee to draw greater attention to this opportunity as part of the reauthorization process.

It should be noted that the semiconductor industry is doing its part to support education. SIA's member survey shows that in the period 2001 to 2005 the combined spending by member companies on K–12 programs is over $250 million with more than 370,000 teachers and seven million students reached by the programs these companies support.

Summary

The U.S. Government, and the NSF in particular, is an important player in the strategy to maintain U.S. technology leadership, at a time when we face fundamental limits on the base devices which have been driving the information technology economy for the past half-century.

Discovering, developing, and implementing a new logic device is a daunting task, but not unprecedented. In the 1940's, when vacuum tubes were the state-of-the-art but were reaching their own limits, the U.S. Government realized there was a critical need for finding smaller, faster, lighter devices for its radar and guided missile systems. A concerted effort began between the government, universities, and industry labs to find alternatives, with approximately $5 billion of federal money (in today's dollars) being invested in semiconductor research specifically to answer this challenge. The result was not only technology to enable advanced weapon systems, but the birth of the solid-state transistor, which became the foundation of the information technology revolution that drives our economy to this day. And it was only the combination of the best basic science research coming out of the universities; the practical guidance and mission-focus of the industrial labs; the significant research funding from the government; and the collaborative interaction of all of these groups that enabled both the scientific breakthroughs and the reduction to practical implementation necessary for such a project to succeed.

We now face a similar transition, as we look for a switch to replace our current CMOS transistor. We are just beginning this research, and the initial efforts are small in comparison to what was done in the 40's and 50's. It is critical we grow these efforts significantly over the next several years, and finding flexible models for industry and government to interact will be critical to success. To this end, in-

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[4] National Academies, *"Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,"* October 2005; available at: *http://www.nationalacademies.org/morenews/20051012.html*

[5] See National Academy of Engineering, "Enhancing the Community College Pathway to Engineering Careers" (2005) at *http://www.nap.edu/catalog/11438.html*

creasing research funding at NSF particularly in the Nanoelectronics area, and expanding NSF's collaboration with the semiconductor industry is absolutely essential if we are to continue our accelerated economic growth and productivity and if America is to lead in the coming nanoelectronics era.

BIOGRAPHY FOR JEFFREY J. WELSER

Dr. Jeffrey Welser is on assignment from the IBM Corporation to serve as the Director of the Nanoelectronics Research Initiative (NRI), a subsidiary of the Semiconductor Research Corporation (SRC). The NRI supports university-based research on future nanoscale logic devices to replace the CMOS transistor in the 2020 timeframe.

Dr. Welser received his Ph.D. in Electrical Engineering from Stanford University in 1995, and joined IBM's Research Division at the T.J. Watson Research Center. His graduate work was focused on utilizing strained-Si and SiGe materials for FET devices. Since joining IBM, Jeff has worked on a variety of novel devices, including nano-crystal and quantum-dot memories, vertical-FET DRAM, and Si-based optical detectors, and eventually took over managing the Novel Silicon Device group at Watson. He was also working at the time as an Adjunct Professor at Columbia University, teaching semiconductor device physics. In 2000, Jeff took an assignment in Technology group headquarters, and then joined the Microelectronics division in 2001, as project manager for the high-performance CMOS device design groups. In May 2003, he was named Director of high-performance SOI and BEOL technology development, in addition to his continuing work as the IBM Management Committee Member for the Sony, Toshiba, and AMD development alliances. In late 2003, Jeff returned to the Research division as the Director of Next Generation Technology Components. He worked on the Next Generation Computing project, looking at technology, hardware, and software components for systems in the 2008–2012 timeframe. In mid-2006, Jeff took on his current role for NRI, and is now based at the IBM Almaden Research Center in San Jose, CA.

DISCUSSION

Chairman BAIRD. Thank you, Dr. Welser, and thanks to all the panelists for outstanding testimony. I will yield myself five minutes now for questions. We have been joined by Dr. Jerry McNerney as well, who is the Vice Chair of the Committee, and I am glad he is here.

One of the issues that I think many of you touched upon has to do with the industrial, the partnership between institutions of higher learning, NSF, and industry itself. And I was intrigued by a number of things.

Dr. Welser, I want to hear a little more about your alternative approach. Describe a little more how that would work, and what the pros and cons would be.

Dr. WELSER. Sure. So, currently, the way we interact mostly with the NSF is through doing funding to university centers the NSF has set up already, or trying to help them put out program proposals that would be in line with the Nanoelectronics Research Initiative or other industry initiatives. Which works quite well, and actually, we have gotten a lot of mileage out of that kind of partnership.

The next step forward that we—which is what we do with DARPA in our Focus Center Research Program, is to actually bring the NSF onboard to the panels that we use, for actually deciding where we are putting our money with—on the industry side, and then, the money that comes in from the NSF. It is still all merit-based, in that all of these proposals come in open, it is an open call for all universities. It is reviewed by scientific members from the industry, and as well as the NSF, then, in that case, or DARPA in

the case of the FCRP. And all the money does go to the universities. There is no money going off to the industry in this case. It is all being funneled back out.

The reason this is good is it allows us to focus programs and focus center research more closely with what we think is the most urgent needs within the nanoelectronics area, and hopefully, we also, then, can help NSF or the other agencies in their other decisions in their other programs, as to where they think they can most help for additional funding.

Chairman BAIRD. I appreciate that. I will make a note to my staff here. I want to have further discussion on that, because it seems kind of intriguing as a model, and I would like to go into more detail on that.

Dr. Ford, I appreciate very much what you said about community colleges producing the workforce for the technical industry. The other Members of this committee have heard a study from my district where major potential—well, current employers potentially are going to spend another $200 million to $500 million in the district. They need several hundred educated workers. They can't find people who can do an average and a standard deviation, and read basic charts. And they are looking, really, to the community college. They are saying look, we need the high level scientists to do the gee whiz stuff, but we need the people who can just make the machines run, and that is requiring some basic skills that are lacking.

How are you—you mentioned a little bit about this. You are partnering directly with the industries through the ATE Program. The industries are coming to you and saying this is what we need. Elaborate on that a little bit, if you would.

Dr. FORD. Thank you very much, Mr. Chairman. Absolutely.

Industry partners are coming to us, but for each one of our programs, our technical programs, we have an advisory committee, and the advisory committee is comprised of representatives from the industry, from representatives from four year institutions, and they help us to determine precisely what those needs are, the skillsets that they require in the industry. The advisory committee is chaired by a representative from the industry, and then, we have standards that we look at, we develop the curricula in all of the training programs to deliver to the employees.

One of the things that we have done that I think is working very well, and that is very consistent with other community colleges, is that we are partnering with public schools as well. In *Workforce America,* a publication that was released a couple of years ago, indicating that as you look at the Nation's workforce, and the requirements in technical areas, that if all of the community colleges and universities were to start today, to start looking at how we prepare the technicians for the industries. They have tremendous needs that we would not be able to fill that void by 2015. So, there is a need.

So, we are now working with public schools on the career pathways, and we are providing the dual credits, so that juniors and seniors who are eligible can come to the community colleges, and they can earn all of the course requirements that are necessary to fill those technical jobs that the industries need. And yes, the in-

dustries do indicate to us precisely what those skillsets are, as we develop the curricula for training.

Chairman BAIRD. Thank you very much. I only have a few seconds left, but I will—we will have a second round.

But Dr. Wise, one of the things I spoke some time back with the University about was the practice of some NSF programs, to limit the number of programs that can get approved per institution. I see the merit of that potentially in your distributing the wealth, but you may not be distributing it in the most efficacious way.

Would you care to comment on that at all?

Dr. WISE. I would actually like to comment on that.

Clearly, I think that there should be some control over that, but I think that it would be beneficial, in terms of value added if that basis was not an absolute number, but a number based upon NSF previous funding, or number of funded researchers at each institution, and I think you are pointing out one of the things that frustrates us so much in the number of applications that we can put in, for example, for IGERTs, where the preliminary number is a certain number, there is a viewing of it, and then, only a certain number of those, that have already been deemed qualified, are allowed for final submission, and it is difficult.

Chairman BAIRD. So, you could put in—you might have a number of potential projects that all are meritorious, but that is pared down, even you had, you know, if you had some of your projects much more meritorious than somewhere else, you would be limited, and someone else might——

Dr. WISE. That is right.

Chairman BAIRD. Yeah. That may not be the most effective way. We will be looking into that.

Dr. Ehlers has an appointment soon, so I want to yield to Dr. Ehlers now.

Mr. EHLERS. Thank you very much, Mr. Chairman. I have another meeting on science-related issues I have to leave for shortly.

First of all, a question for all of you. Do you have personal acquaintanceships or relationships with your Members of Congress or your U.S. Senators? Any of you?

Dr. HUNT. In other words, do we go to their office and visit and talk to them?

Mr. EHLERS. Yeah, or from your home district, preferably.

Dr. HUNT. I do.

Mr. EHLERS. You do. Good.

Dr. HUNT. Yes.

Mr. EHLERS. Anyone else? Okay. Yes, Dr. Ford.

Dr. FORD. We have a Governmental Relations Office that usually meets with our Congresspersons, and occasionally, they will come to our campuses, and we interact with them.

Mr. EHLERS. Okay.

Dr. WISE. We, too, have advisors from Senators and Congressman——

Mr. EHLERS. Okay, good. I certainly want to encourage that, because I noticed almost all of you said NSF should have more money. Now, the fact that it doesn't have enough money is not our fault. We are great advocates of the National Science Foundation, and want them to have their funding increased.

Today, we had a big battle on the floor about the budget for next year, and I have fought, as I suspect the chairman has fought, for increasing the numbers for what is called Fund 250, which includes the National Science Foundation and other research. It has gone up perhaps a micron or two on the scale, but there is a long ways to go. We need all the help we can get, and the scientific community really has to become active. They have not been as active as they should be in seeking funding for the National Science Foundation, Department of Energy, and so forth. And that is not true of all scientists. Some are extremely active, but I hope all of you will become active, and recruit others to become active.

I recall when Chairman Sensenbrenner was the chairman of the Science Committee, and scientists came to him and asked for money for a project, his first question was: "Have you explained this to your local Rotary Club?" And which was always greeted with surprise, you know, why should we? He said: "Well, if you can't convince them this is worthwhile, how do you expect me to convince my colleagues it is worthwhile."

The Congress starts from the bottom up, so I hope you will join in that. We have someone in the audience who spends most of his life lobbying for money and has a good friendship with many Members of Congress, and I would like to see that replicated many times over.

I—first of all, Dr. Ford, I appreciate what you are doing, because I have been leading the charge on improving STEM education, science, technology, engineering, mathematics, and the response I get from a lot of people is well, you just want to produce more scientists and engineers, because you are a scientist. The real point of it is to do precisely what you are doing. The kids who are in school today will not have jobs if we don't educate them for the jobs of the future, and that is precisely what you are doing.

Now, the reason the community colleges are doing it is because the schools are failing to do it. The elementary schools, by and large, are not getting them prepared or excited, and I just read an article recently about the fact, compared to most developed countries, the United States is way down, as we all know, in the fourth grade level, the eighth grade level, and the high school senior level, compared to other developed countries, in the students' knowledge of math and particularly physics, but also, other sciences. And the article went on to point out, and they had done some research on this, the reason we still succeed fairly well as a Nation, because of our community college system, so that students who do not learn these things in school go to the community college, spend a couple of years there, and then are able to get into the universities where they finally hit their stride.

Now, that is wonderful but they can do this, but it is a very inefficient way of educating students. So, I just wanted to thank you for what you are doing, but also, recognize that you are so successful only because we are failing elsewhere.

I think I have to run, so I better stop here, because my next comments would be much longer. But I do want to thank you for your interest and the insights you have presented here is very good, precisely what we need.

Dr. Ford, do you want to——

Dr. FORD. Yes, thank you very much, Ranking Member Ehlers.

I would like to thank you for your remarks, and would like to indicate that based upon the data that we have found, national data, that they would indicate that the students who begin with us at the community college, often they come in, and they don't have all of the competencies and skills required, but by the time they exit, they do have all of the competencies and skills required.

When they transfer to a four year university, that the community college student transfers perform just as well or better than those students who began at the university level as freshmen.

So, that, really, was very, very positive feedback for all of the community colleges, recognizing that many of our faculty members were trained at the university, and many of the faculty members who teach for us part-time are the same university faculty members. So, the students who come to us are getting that interaction and that interchange from the brightest minds, both at the community college, as well as from the university.

So, thank you very much.

Mr. EHLERS. Well, using a religious motif, you are here providing salvation for people who desperately needing it.

The other interesting thing, too, is that the route through you, if students are not prepared, is a much better route, because I have looked at the data from major universities, and the number of students who fail because they are not properly prepared in math and the sciences, is much higher than it should be, and that means these students who are not prepared for a number of reasons, tend to really have a terrible experience, in some cases, just dropping out totally. Those students should have probably gone to your school or a similar school, to get what they needed to succeed at the university.

This is particularly true with some of the figures I have seen about high school mathematics, and attempts to implement new approaches without checking with the universities, and they end up with high school graduates who are extremely adept at certain parts of mathematics, but still can't get it, can't succeed in the calculus, because they just didn't cover the material that the universities expect.

Thank you very much for being here. I apologize that I have to run, but thank you for the wisdom you have shared with us. I appreciate it.

Dr. WISE. Thank you.

Dr. FORD. Thank you.

Chairman BAIRD. Thank you, Dr. Ehlers. Dr. McNerney is recognized for five minutes.

Mr. MCNERNEY. Thank you, Mr. Chairman. I want to thank Dr. Ehlers, too, for his insightful comments.

It is a pleasure to work on this subcommittee, because there is so much educational level portrayed, and we have gone through the rigors in this committee, and I see from your credentials that you all have gone through the rigors of discipline, and as a consequence of that, you understand the rewards of that hard work, both emotionally, intellectually, and in terms of your career, and maybe financially. And so, that is the joy of sitting here on this panel and listening to a group like this.

Now, unfortunately, I think we have seen a devolution of interest in technical subjects in the lower levels of education in this country. And I hate to say it, but it just plain isn't cool to be a nerd, to work hard for something that is long off into the future in our country, and to develop the skills needed to be a successful scientist. And that is the challenge that we have, and that is a challenge I am presenting to you is how do we change this culture?

A little money from NSF here and there is going to be good, it is going to be helpful, but we need to get the young children in this country interested in putting in the hard work, both because of the reward, financially and to the country, but also the reward they get intellectually. We have seen a lot of young people running around with the disrespect and so on, and now, it is time for us to change. The paradigm has to change. We have to reach a tipping point where this country moves toward understanding the magnitude of the challenges that we are facing in the next century, and that is up to them, that generation, the next generation, to rise up and meet those challenges, because if they don't, we are going to be devolving economically into a Third World country, so that is my preaching.

And I have a few questions on the end of that. Dr. Wise, I guess this isn't really a question. You have some very good ideas and very good visions of where we can go, in terms of our scientific work. You said underwater mapping, the ocean floor, and so I think that is very exciting. And you also mentioned the manipulation of large, complex datasets, and I think Dr. Welser mentioned the human genome recently, mathematics, and I am a mathematician, had a very big discovery on E8, and that is the most complicated structure ever studied. It is a 258 dimensional object, and just the fact that we can corral that sort of an object, and map it out so that it can be understood, is a tremendous achievement for the human condition.

So, that wasn't really a question, just a comment.

Dr. Hunt, you called for a symbiotic relationship between academia and industry, and I think that is very important. I have spent my career in industry. I have a Ph.D., so I do understand the need for that. And my question is this: do you think the National Science Foundation is doing enough to sort of foster that symbiotic relationship, and if not, do you have any specific suggestions or ideas of how we could proceed down that road?

Dr. HUNT. So—I do. I think this is a great subject, and it hits me both as President of the ACS, where I represent by members, but it also hits me right squarely on my job at Rohm & Haas, which is to build that relationship between industry, academia, and national labs for cutting edge science.

And so, I think the NSF has certain programs, and we actually work with those programs. We have associations with professors who have GOALI grants, as well as being part of NIRTs and IGERTs, and other programs like that. But when professors come and approach us, that are just starting out, they many times are not aware of these programs.

So, I think that there could be more, a broader knowledge of these programs, because the professors who do have them, and once we start working with them, and they become part of these

programs, they say our students, every one of our students, should have a GOALI, because every student who has a GOALI gets a job, because they get it. Whether it is in academics or industry, they get that connection between forming the idea, and envisioning it to a final product, even if they are not looking at commercializing it, they understand and they can see the whole throughput.

We also have the students come and work in our labs, and we, the PI on our project, co-PI, goes to the university, so I would love to see more of that, and I understand the NSF is also looking at broadening some of these programs, to be more, well, for instance, the NIRT is more than one professor at one university, so I think as you move forward, you develop those team collaborations.

So, I would love to see them build on these programs, and I think that the legislation that we are talking about here today, or talking about the reauthorization of NSF, will move us in that direction.

Mr. MCNERNEY. Thank you for your answer. I think I have run out of the time. Will you allow Dr. Wise——

Chairman BAIRD. Absolutely.

Dr. WISE. If I could comment on your comment, your earlier comment about how young these children should be when they are first exposed. We have a program that brings kids on to campus for a couple of days when they are eight years old, to show them that science, engineering, and math actually is fun, it is not for nerds. It is actually cool to do. We take them into our labs. We show them some experiments, and we follow these kids as they get older.

So we, I think, are beginning to realize, at the university and industry level, how critical it is to take these young minds while they are still soft clay, and really mold them to realize that careers and professions in science, technology, engineering, and math are invigorating for your whole lifetime.

Mr. MCNERNEY. Thank you.

Chairman BAIRD. We have been joined by Mr. Lucas from Oklahoma, who will fill in as Ranking Member, and he also has to catch a flight about 4:15, so we will give him a bit of extended period of questioning, if he likes.

Mr. LUCAS. What a tremendous temporary promotion. Thank you, Mr. Chairman. I am fixing to go out across the countryside, like a lot of my colleagues in this next couple of weeks, and visit with my good constituents, and a goodly number of town meetings that I will do.

And with science being one of my three committee assignments, in the eyes of my constituents, not always is it a committee that generates the kind of discussions that the Agriculture Committee, or for that matter, the Financial Services Committee, generates.

But I guess a question I would like to put to the panel, and anyone who would care to touch on it, when interacting with my constituents, how do you recommend, or what kind of response do you give, what kind of comments do you provide when the classic question comes up about our efforts, our current efforts to bridge basic and applied research? How do you explain, if you were in my 20 town meetings I will do over the next two weeks, why those two things are interconnected, and how are they interconnected?

Man, that is a tough subject.

Dr. WELSER. I will take a shot at it.

Mr. LUCAS. Please, Doctor.

Dr. WELSER. I think if you look at like what we are trying to do with finding a new switch for computer chips, right now, what we are studying is the spins of individual electrons that float around in semiconductor metallic materials. I can guarantee you this is basic science research. I don't understand half of it myself, but from that research, we already start to see someone saying well, look, I can make this one go up on this side and down on that side. Well, that is a 1 and a 0, that is a switch, that is the next, that could be the basis of a new computer chip.

So, that kind of really simple idea, that electrons, individual electrons spinning up and down, can suddenly drive your whole computer in the future, that is the connection that I try and look for myself, when we go to figure out which of the basic science areas we are going to go invest in.

Mr. LUCAS. And the kind of place that no practical application company could do the preliminary work, spend the years, come from the various different angles that you do.

Dr. WELSER. Absolutely.

Chairman BAIRD. Mr. Lucas, if I may invite, Dr. Wise had what I think——

Mr. LUCAS. Please.

Chairman BAIRD.—would be a great example of some research that her people did on mosquitoes.

Mr. LUCAS. Please. Oh, mosquitoes.

Dr. WISE. Well, the example that I used——

Chairman BAIRD. Turn your mike on there.

Dr. WISE. The example that I used was that two researchers at the University of Washington were interested in insect development and learned about the hormonal regulation of that development. That allowed us to develop pesticides. That also allowed us to develop ways to control reproduction of mosquitoes, which are the vector for malaria.

I mean, if we knew exactly how to go from the very fundamental to the very applied, we certainly wouldn't waste our time on things that are very esoteric, but the amazing thing about the NSF is that its funding has allowed the quality of the lives of Americans, but actually, people and animals and plants around the world, to really benefit from serendipitous findings that we could never predict would go from one place to another.

The discovery of enzyme inhibitors that allow us to can food was not from an investigator who was trying to make canned food stay on the shelf longer. It was just this wanting to understand the metabolism of bacteria. The study of the human genome was not done by someone who really wanted to understand DNA sequences. They were just studying enzymes that broke DNA and bacteria, that led us to be able to develop the mechanisms, and then, the computers that were used to be able to do the human genome. It is an amazing—the magic of the NSF is truly in its respect for the human intellect, to be able to be creative, and driven by ideas of discovery, and not really trying to cure anything or fix anything specific.

Mr. LUCAS. Dr. Ford.

Dr. FORD. Thank you very much. I will be brief.

I think one of the best examples, but not in the purest sense, of a laboratory for applied research, is the local community college. Because you, in effect, have individuals who come there, and as a result of the grants that are funded by NSF, whether it is S–STEM, or whether it is the ATE, you are able to have individuals who have scholarships, who have the faculty support, to enroll in the programs, and then transfer to senior level institutions. We have substantial data to show that many of the students who are academically capable but financially needy, are able to come into the AAS degree programs in STEM areas, or into the associate in science degree programs, and then transfer very successfully to senior level institutions in STEM programs.

So, I think that is a concept that they would understand, and they would be able to go to the community college, and see many, many examples of that. Thank you.

Mr. LUCAS. I promise you, Dr. Ford, I am a true fan. My freshman year was at a community college, before I then transferred to a land-grant institution, so yes, all of the reasons you have just described.

With that, Mr. Chairman, thank you for this hearing, and very insightful panel.

Chairman BAIRD. Mr. Lucas, thank you very much, and when the time comes, if you need to leave, we will only continue the hearing just very briefly for the purpose of taking testimony.

Just a couple of remaining questions from me.

Dr. Meriles, you talked about the career merit review process, and I think you raise a very good point, because there is a bit of a Catch-22. If you are young and new, and have the energy and all the enthusiasm, and maybe cutting-edge knowledge from just having completed your dissertation or postdoc work, then you suddenly get to a university. You have got to gear up the hardware, try to get a team onboard, et cetera, you are under tenure pressure, and you are applying for grants, and it is sort of like a rookie in baseball, they are saying well, what have you done in the majors yet kid? Well, coach, I haven't even been to the plate yet, here.

So, how do we do that? How do we do that better? What should we look for? What should we tell NSF to look for in a different way?

Dr. MERILES. My impression is that young faculty need lots of opportunities, different kind of opportunities. The CAREER Award is a great way to get started, and particularly, if you work in experimental, if you do experimental research. Then you are going to necessarily have to get equipment for that, and the CAREER Award may become, perhaps, one of the few ways that you are going to be able to put together the infrastructure that you need. But—so my point was that sometimes, you have the idea, you have the will to go for that idea, and the idea might be pretty good, but sometimes, you are in an environment that, and you know, lacks the infrastructure to at least get started.

And as I said, in physical, in experimental science, it is fundamental that you have some piece of equipment to get started. So, it is not in particular in my case, I got some startup, and I could have some preliminary data to show in my proposal, but that, I know, is not general case. I see people with great ideas, that in the

end, are not successful, simply because well, when the competition is so tight, then you are going to go for proposals that not only have the idea, but also have the experimental results, and you know, once you have the experimental results, perhaps something else.

So, my impression is that perhaps even if it is not within exactly what we understand now as a CAREER Award, but perhaps through some pilot program, people may have the opportunity to get started somehow, and get a proof of principle, of what their idea is, and so, move from there.

Chairman BAIRD. It occurs to me that it might be an interesting exercise for NSF, and this is just thinking off the top of my head, to select a number of programs that would not normally get funded, fund them, and then follow up and see the outcome data of the potentially rejected versus the actually accepted, and see if the effectiveness of the research, you know, really test your screening process, so to speak, by selecting the non-selected, and following up a ways, and seeing what happens. It would be worth maybe doing a few samples of that, especially in the kind of realm you are talking about, where somebody is taking some innovative ideas, maybe a little higher risk, but maybe potentially, a much greater payoff in that.

Dr. MERILES. Because I mean, somehow, at this point, you run into a position where it is all or nothing, and so, either you get granted, or in the end, you don't, and if you don't, then you fail. And I believe that that is, somehow, unfair, because the environment is not the same everywhere, so you need to open up, to have some opportunities for people coming from different origins and having different backgrounds around.

Chairman BAIRD. Somewhat related to that, I will keep returning to this theme about partnerships, and Dr. Hunt, you alluded to it, Dr. Meriles, you talked about partnerships, and—what are—what specific kinds of things, to the panel in general, but particularly, maybe, for Dr. Hunt or Dr. Welser, through your organizations, and you have already alluded to some of the NSF grant programs that you work with—how would we do this better? And I know more money, fine, fine. We will do our best. But let us suppose money is finite, which it is, how do we do things better? How do we better leverage the money? When Dr. Wise testified, she talked about the amount of money that NSF contributes to her academic institution, but that is actually a fairly small number, relative to the total research budget you alluded to, so there is a lot of leveraging. How do we better structure NSF grants or other programs for leveraging partnerships?

Dr. WELSER. I will start and——

Dr. HUNT. Okay.

Dr. WELSER.—I will let you jump in. I think that one of the things that we found very useful in not only the work we do with the NSF centers, and the NSF grants that come in, but also, some of the other ways we fund the universities, is to make sure that we have liaisons from the industry who are actually actively following the specific research programs.

So, for example, every time we do a joint funding with the NSF at one of their NSECs, we actually have a liaison team from every

member of the—every one of our member companies, who is in charge of going to that center at least once a year, as well as having regular, you know, telecons on a quarterly basis, to keep, not only to keep track of it so that we understand what is happening, but hopefully, to give our guidance from the industrial side, as to what we think might be ways to go.

And the flip side, then, we also try very hard to get the students who are working on that to come in for co-ops in our companies, or internships, sometimes it is challenging, because the professors want, you know, to keep them on campus to do their research, but we always find that if they do come in for even three months or six months, and work in the companies, overall, it not only accelerates their ability to complete their thesis, but also, prepares them better in the end for working on the industrial side, if that is what they choose to.

So, perhaps also putting that in as part of what you are doing in your grant, money availability for actually, the travel, the expenses for doing the co-ops and internships, to share with the industry, would be great.

Dr. HUNT. So I guess I would say, one is you could promote these programs more, two, with some of the other agencies that I work with, DOE and DOD, there are requirements on the partnerships, so if you do that, I even find that it is a great way for me to encourage my company to partner more, because in order to get this funding and attack this problem, if you are made, encouraged, required to have a certain team, that will promote the partnership. So, in some ways, it is a pull, as opposed to a push, and once you get it going, it is like turning on the engine. It runs.

Rohm & Haas is a member of the SRC, and so, I also think that it is a good model of how you get people together to collaborate around a given program, like electronics materials, which is, you know, 20 percent of Rohm & Haas' business, and so, it is very much of a focus for us.

I think that, and also, one thing, I am also on the executive board of the Council for Chemical Research, which one of our main goals is collaboration. And so, what we have done, we have actually collaborated with NSF to have workshops to bring together people from across industry, academia, and the national labs, so that you bring them together. I had one professor say: "I don't want a requirement to work with industry, because I don't know anyone in industry." And I said: "Well, you know me, so don't say that."

And so, I think we need to get people to think more broadly about partnering and the importance of partnering, and I think once you do it, you find that wow, you get there faster, and so, it is, in some sense, it is making it happen.

Chairman BAIRD. One more thing. And it is partnering not only between the university and industry, in many case. I think the partnerships between professors——

Dr. HUNT. Yes.

Chairman BAIRD.—within universities and across universities, is really crucial. I think one of the things that the NSECs do quite well, on the NSF side, as well as the, like the centers that we do for SRC and the NRI Program, is that we require the proposal to come in from various universities and professors across disciplines.

And that forced communication, it is not natural for professors to go, to work that way, of course, initially, but almost inevitably by the end, they do appreciate that.

At our first annual review in November, we had to drag some of them in, because you know, travel money is always tight, but they all stayed right until the end, and continued talking long after the meeting was over, because that was their only opportunity to really interact with some of these other professors on topics that they have great passion about.

Dr. WELSER. So, you feel those aspects are working pretty well.

Chairman BAIRD. Yes, absolutely.

Dr. HUNT. I guess I wanted to reinforce what we said earlier about the NIRT, when universities have a limited number, because you go through putting that collaboration together in order to get it through the university stage, and when you then don't get selected to be the group that goes forward, it is—disheartening may be a hard word, but it is.

Chairman BAIRD. You put a lot of human effort into this.

Dr. HUNT. And then you have another year before you can apply again. Now——

Chairman BAIRD. There is a lot of opportunity cost in preparing a grant.

Dr. HUNT. That is exactly right. And when you talk about, you know, your success rate, if you have to write ten grants to get one funded, that is a lot of time.

Chairman BAIRD. Dr. Wise.

Dr. WISE. I would make a suggestion in terms of how to enable junior faculty to be able to get funded right off the bat. I know the statistics for the NSF are that 28 percent of the established investigators get funded, whereas only about 17 of the junior ones.

If the cutoff was 10 percent, so the top 10 percent of the grants would get funded, but the study section was allowed, or the NSF was allowed to fund down to the 20th percentile any grant between the 10th and the 20th percentile, that was a first grant for a junior investigator, basically, the first 20 percent of the grants are all highly meritorious, and it is very arbitrary that you can only fund 10, but if you could pick and choose from that next 10 percent, so that only assistant professors applying for their very first grant would get the money, you would then be selecting and favoring those that are still highly meritorious, but have never had a grant before.

Chairman BAIRD. We have, and some of the language in H.R. 363, provisions to shift some of the research funding to earlier career investigators, and I think, and I don't know that we have exactly codified the mechanism you have described, but it is an interesting way to approach that problem.

I want to thank all the panelists, and some of you have come a very, very long way, and taken a great deal of your time, and I want to assure you that these hearings don't end here. I have a to-do list already, the best hearings here are not the ones where the Members yak and make speeches. They are where you folks give us your expertise, which far exceeds ours, and we can take notes, and go back, and try to incorporate these.

Some will be, you will be able to see, I think, in the hearing, or in the ultimate bill, what we have at least tried to address some of the elements that have been brought to our attention today. And I am grateful for that. It has been very enlightening for myself and my colleagues, and I assure you, too, that Members who are not here in person will check very carefully the record when they get back, and we will have a lot of discussions about your input, as we move towards a final draft.

So, thank you very much for your time, thanks also to the folks who are here in the audience, and thanks again for staff and their work.

And with that, this meeting stands adjourned. Thank you very much.

Dr. HUNT. Thank you.

[Whereupon, at 4:20 p.m., the Subcommittee was adjourned.]

Appendix:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Phyllis M. Wise, Provost, University of Washington, Seattle

Questions submitted by Representative Ralph M. Hall

Q1. You provide some interesting examples of research solving problems it was never designed to solve. This is relative to the role of industry partnering with NSF, as well as NSF-funded institutions. What is the appropriate balance between identifying applications and pursuing them at the cost of serendipitous, fundamental research? What prevents industries from seeking NSF partnerships?

A1. Typically, research in the private sector is driven by evident need and application, and it is likely that less serendipitous discoveries will take place in industry-sponsored research or in public-private partnerships. Although of course there are numerous exceptions to this, especially for companies such as Microsoft and Bell Laboratories, who have invested heavily in the past in fundamental research. Fundamental (basic) research should remain at the center of NSF, as this is one of few sources of funding for university researchers that can and should encourage risk taking. Unfortunately, as research dollars become tighter, review panels tend to become more 'conservative' in their expectations, and less willing to fund 'risky' research. NSF should in fact seek out 'high risk—high reward' research, perhaps with some designated programs designed to explore the outer boundaries of important questions. Something akin to the 'Grand Challenges' approach developed both by the NIH and the Bill and Melinda Gates Foundation is worth exploring.

Q2. Most of you have touched on the difficulties faced by early career scientists in setting up their labs, beginning teaching loads, recruiting students, and above all, preparing for tenure review. Could each of you please address the challenges that the tenure process creates? Does the Federal Government have the ability to lessen these challenges?

A2. At most universities, including the UW, the tenure decision process begins early in the fifth year of an Assistant Professor's appointment. Thus, the investigator has only four years to become established as an independent investigator. Frequently the first year is consumed by setting up a lab, buying equipment (assuming that start-up funds are provided), hiring staff and/or recruiting new graduate students, preparing new lectures, advising new students, establishing collaborations with new colleagues, etc. It is a rare junior faculty member who is able to show much measurable productivity (e.g., published papers, funded grants) in their first year. Most 'investigator-initiated' grant applications are expected to contain significant amounts of preliminary data to demonstrate that the investigator is capable of designing and conducting successful experiments, and that the fundamental premise of the hypothesis is valid. Collecting such data requires months of research, such that it may be well into the second year before a viable grant application (with preliminary data) can be submitted.

Assuming that the faculty member submitted his first grant midway through his second year, review and possible funding takes at least nine months from the time of submission, pushing him into the third year. If not successful, revision and resubmission will take at least another full year (e.g., well into the fourth year). Likewise, the publication process is often slow. Once experiments are completed and data analyzed (a process that may easily take a year), the paper must be written (another few months) and submitted for peer review. The initial review process may take another two to three months, and usually will require revisions and re-review (another three to four months) and may require that more experiments be completed. Even in the most efficient laboratories, it generally takes at least a year from the time an experiment is begun to the time a paper is 'accepted' for publication.

From the conceptual time table above, it becomes evident how challenging it can be for a new Assistant Professor to have a 'demonstrated track record of accomplishment' (which is almost always measured in numbers of publications and grants submitted and awarded) in four years, with tenure review beginning early in the fifth year. Most new assistant professors will also be expected to teach (and perhaps even develop new courses), which is also time consuming and detracts from time available for research. What role can the Federal Government play in 'lessening the challenges' of tenure review? The primary way that the Federal Government can help is to ensure that funding agencies such as NSF have adequate resources to devote to funding of new investigators. This also requires some education of grant peer reviewers (who are external to the funding agency, but make the initial assessment of the grant application) to ensure that their expectations for 'preliminary data' and

publication record of the new investigator are not unduly high. Recognizing that the rejection of a first grant submission will likely delay significant progress by well more than a year, it becomes obvious that most new investigators do not have the time to go through two or three re-submissions. In many circumstances, a third revision may be too late.

It is also important to ensure that the investment in new investigators is made wisely. It is certainly the case that not every new Professor is cut out for a career in research, and the institutions rely upon effective peer review to ensure that the faculty that receive funding are indeed competent researchers. I provided the example that if grants were funded for all investigators to the 10th percentile, allowing grants submitted by new investigators to be funded which were between the 10th–12th percentiles would provide them with funding. Usually the difference in merit of proposals in these highest percentiles is not significant and thus we would not be 'lowering the bar.' In addition, streamlined resubmission and re-review processes for new investigators that come close, but are not funded the first time, would be a substantial improvement in the current review process.

As noted in the submitted written testimony, the proposed NSF Charter did include language for a new program that could help to solve some of these problems: Section 6 "Establishes a pilot program in which excellent proposals from new investigators that are not funded by the merit review committee can be funded for one year, at the discretion of the program officer, with Small Grants for Exploratory Research (SGER)." This is an innovative approach to addressing the challenge of new investigator funding. This approach does not circumvent the peer-review process, yet will allow promising new investigators short-term funding to collect critical "proof of principle" data that are increasingly required to compete successfully for a full NSF award. Providing NSF staff with the authority and resources to decide which new investigators do and do not get such pilot funded is a reasonable approach for streamlining this process. Of course, a key issue will be, "how far the money can go." For this to be successful, appropriation of significant resources to this program will be necessary.

Other programmatic ways of shortening the 'start up' time and ultimate success in the tenure process for outstanding young faculty would be to develop four- or five-year career transition awards that a post-doctoral fellow could submit during his/her fellowship years that would fund one or two additional years of post-doctoral training plus the first three or four years of a new faculty position. The Burroughs-Wellcome Fund has developed a program similar to this (called the 'Careers Awards at the Scientific Interface,' but this is targeted for a narrow 'niche'—physical scientists or engineers pursuing research in biomedical sciences. See: *http://www.grad.wisc.edu/research/resadmin/bwfcasi08brochure.pdf*)

Q3. You mention in your testimony that "Asking creative people to solve a defined problem is not the path to discovery." Along the lines of allowing unfettered research to take place, what is the current tenure environment like at research institutions, and do you feel like taking risks is acceptable in that culture? How can the university manage/encourage certain perceptions?

A3. In general, most of our junior faculty are actively encouraged NOT to take risks in the beginning stages of their careers. For many of the reasons delineated in Question 2, there is little time for 'failure' of a good, novel idea that, in the end, just doesn't work. The advice is generally to 'focus, focus, focus,' and to hedge your bets on relatively 'safe' research that is pretty much guaranteed to produce publishable results. Many novel ideas, even with supporting data, have a difficult time getting published the first time, and publication record at the time of promotion (and tenure) review is arguably the most important criteria for promotion and tenure. However, risk taking is certainly appropriate for Associate and Full Professors who have lesser burdens and time constraints on productivity than junior faculty, and there is nothing in the tenure environment that would dissuade senior faculty from risk taking. But creative ways of funding such faculty that encourage risk taking are needed. The 'Pioneer' awards at NIH are an example of such a program.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Catherine T. Hunt, President, American Chemical Society

Questions submitted by Representative Ralph M. Hall

Q1. Most of you have touched on the difficulties faced by early career scientists in setting up their labs, beginning teaching loads, recruiting students, and above all, preparing for tenure review. Could each of you please address the challenges that the tenure process creates? Does the Federal Government have the ability to lessen these challenges?

A1. The long-established academic tenure process is rigorous and demanding on young investigators. While there is little the Federal Government can or should do to directly affect the tenure process, there is much the federal research agencies can do to increase the availability of basic research funding in the physical sciences and thus provide greater support for tenure-track faculty in these fields. Robust federal funding for research and development in the physical sciences—chemistry, physics, engineering and other fields—plays a vital role in providing an environment in which future generations of scientific researchers can succeed. Ensuring that key research agencies like NSF, NIST, and the DOE's Office of Science have ample resources to keep the physical science fields vibrant and innovative is a principle mechanism for attracting our best and brightest students into academic careers.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Margaret F. Ford, President, Houston Community College System, Northeast

Questions submitted by Representative Ralph M. Hall

Q1. Most of you have touched on the difficulties faced by early career scientists in setting up their labs, beginning teaching loads, recruiting students, and above all, preparing for tenure review. Could each of you please address the challenges that the tenure process creates? Does the Federal Government have the ability to lessen these challenges?

A1. Community Colleges do not face the same challenges faced by senior-level institutions regarding scientists' laboratories, beginning teaching loads, recruitment and tenure review. Typically, community college professors teach a standard load—often twelve to fifteen semester-credit hours of coursework—which would comprise a maximum of five courses for a standard load. University Professors often teach fewer contact hours but are engaged in research as a part of their academic load. Both the "Open-Admissions" University and Community College professors do, however, have similar challenges recruiting sufficient numbers of academically prepared students into STEM-pathways. National Science Foundation support through its funding that positions community colleges as the bridge between public schools and universities (C–STEM and S–STEM) is creating a viable pipeline of students for the future.

Challenges that the Tenure Process Creates:

In my estimation, the issues and challenges of the tenure process are more institution specific and require institution-specific solutions. According to the American Association of Community Colleges data, about 51 percent of full-time public community college faculty are tenured, while another 35 percent are not in a system with tenure available or are not in a tenure track. Only about 14 percent of full-time faculty at public community colleges are in a tenure track and do not have tenure at all. As Tronie Rifkin wrote in her publication for AACC, the community college professoriate is distinguished by its mission, size, diversity, and educational background. A hallmark of faculty members in this sector is a commitment to teaching all students, particularly nontraditional students and those who might not otherwise have access to higher education. For community college professors, excellence in teaching and maximum student success are the primary focus versus the focus on academic research.

Does the Federal Government have the ability to lessen these challenges?

Issues pertaining to tenure should be addressed specifically by the institutions. The Federal Government can provide much needed support to institutions through the following: continuation of funding for faculty research initiatives, in continuation of funding for community colleges in STEM-fields to create STEM career pathways for high school students, and in new funding to support the critical area of Teacher Education.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Carlos A. Meriles, Assistant Professor of Physics, The City College of New York, CUNY

Questions submitted by Representative Ralph M. Hall

Q1. As a young investigator, are you asked to frequently participate in peer review? Do you have a feel for whether the frequency is similar to more established researchers? How could NSF get more peer reviewers who would be open to new ideas and potentially "risky research"?

A1. My impression is that young investigators are, on average, less frequently asked to serve as a peer reviewer than established investigators. I do not feel, however, this is intrinsically unfair. In listing reviewers for a proposal, investigators are naturally prone to suggest (more) senior colleagues given their visibility and demonstrated expertise. Likewise, evaluation committees are more likely to give more weight to reviews by more senior scientists. However, young investigators can often provide a fresh, "out-of-the-box" insights, which could be very helpful to NSF program managers. No exact formulas apply in all cases, but, in my opinion, proposal review teams generally should include at least one younger researcher. This practice is healthy not only for NSF but for young investigators, as well. Participating in the review process serves as a learning experience for young investigators that may ultimately translate into improvements in their own research proposals.

How to identify reviewers open to potentially transformative but "risky" projects is an important issue and deserves special consideration. To start with, the very definition of 'transformative research' is not at all clear. To the best of my knowledge, NSF lacks specific criteria for identifying such research. As a first step NSF should establish clear criteria and guidelines that allow reviewers and panel members to identify and separate projects that fall within this category. Once selected, panelists must be instructed on how to deal with such proposals. In particular, they must be provided with a clear framework that indicates how to weigh creativity and potential impact versus chances of success; for example, in evaluating the risk of a transformative project, the background of the PIs (even in the case of young researchers) could be given a higher weight than usual. The NSF could also recruit a special pool of reviewers whose research track record shows exceptional creativity and extremely high scientific impact.

Q2. Most of you have touched on the difficulties faced by early career scientists in setting up their labs, beginning teaching loads, recruiting students, and above all, preparing for tenure review. Could each of you please address the challenges that the tenure process creates? Does the Federal Government have the ability to lesson these challenges?

A2. Faculty tenure in higher education is, essentially, a presumption of competence. In general, but particularly in the hard sciences, decisions are made first and foremost by the level of external funding and the number of publications and its impact—usually inferred indirectly from a variety of parameters such as the journal reputation. Teaching evaluations (by more senior colleagues and students) and contributions to departmental tasks play a role as well but, in my experience, the latter are not as heavily taken into account, especially at research-oriented universities.

Obtaining substantial grant support represents, I feel, the most important challenge young investigators face. For experimental scientists, sufficient funding is inherently tied to the ability to provide an adequate laboratory setting and attract students; ultimately, it impacts the quality of the research he/she will be able to carry out. At small- and middle-sized colleges and universities, problems become more acute, often due to the lack of adequate human and physical infrastructure. Thus, NSF ought to make every effort to identify and nurture promising young investigators, particularly in these institutions. I indicated in my testimony that a wider palette of programs for young investigators as well as a more agile and briefer review process could be part of the solution.

Women in science research face an additional set of challenges. These stem from a number of sources; for example, women with children often have a comparatively greater share of the child-rearing responsibilities. Obviously, this affects the ability of female scientists to effectively compete with their male peers. Some institutions, such as The University of California and Ohio State University, have instituted the option of 'half-time' tenure track for primary caregivers. One possibility is that, in these cases, programs for young investigators be extended accordingly.

Question submitted by Representative Jerry McNerney

Q1. You suggested that NSF should consider creativity and inventiveness in judging proposals. You also gave some suggestions including timing of RFPs and timing of publications, but judging novel and creative ideas would surely involve more than just administrative considerations. Do you have some ideas that would get to the heart of a creative proposal?

A1. As you implicitly indicate in your question, the problem of identifying exceptionally creative proposals is indeed very complex and must be dealt with special attention. Ideally, creative proposals must be evaluated by individuals who appreciate and understand risk-taking. It is difficult, if not impossible, to identify *a priori* who those individuals are. But it is likely that reviewers with an exceptional, accredited creativity record be more open to consider such proposals. That is the reason why I indicated above that NSF ought to select and attract a special pool of reviewers assigned to this specific task. At the explicit request of a program officer or the evaluation panel, creative but "risky" proposals may be submitted to an investigator in this group for review.

Another possibility is that, once evaluated by reviewers and panelists, proposals that are deemed creative but risky could be sent to the PI for clarification. Novel ideas are often misunderstood and a timely rebuttal could make a difference. Program officers often play a significant role in the selection of a proposal. For this reason, it is also important that they be trained in identifying and weighing potentially transformative ideas. Finally, it is important for NSF to establish a mechanism that enables administrators to track the rate of success of risky research. In the medium term, this will facilitate setting a baseline and making corrections if deemed necessary.

ANSWERS TO POST-HEARING QUESTIONS

Submitted to Jeffrey J. Welser, Director of the Nanoelectronics Research Initiative, Semiconductor Research Corporation

These questions were submitted to the witness, but were not responded to by the time of publication.

Questions submitted by Representative Ralph M. Hall

Q1. Most of you have touched on the difficulties faced by early career scientists in setting up their labs, beginning teaching loads, recruiting students, and above all, preparing for tenure review. Could each of you please address the challenges that the tenure process creates? Does the Federal Government have the ability to lesson these challenges?

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