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

HEARING CHARTER

National Science Foundation Reauthorization: Part II

Thursday, March 29, 2007
2:00– 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 multidisciplinary teams of scientists, engineers and educators. In addition, individual directorates have their own interdisciplinary and multidisciplinary coordinating activities. For example, the Mathematical and Physical Sciences Directorate has a separate Office of Multidisciplinary Activities, which facilitates, coordinates and co-funds multidisciplinary 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, multidisciplinary 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 multidisciplinary and interdisciplinary as follows: Multidisciplinary 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,

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[1] Robert Day, CEO of the Keck Foundation

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 5-year period. NSF-wide, the average annualized award amount for research grants in FY 2005 was $143,600, and the average duration is 3 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 2-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 2-year colleges?