Appendix D: Program Evaluations

D.1 Committee of Visitors Meetings Through FY 2011

DIRECTORATE/OFFICE *Division* Program or Cluster	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
BIOLOGICAL SCIENCES		
Biological Infrastructure	2007	2010
Environmental Biology	2006	2009
Integrative Organismal Systems	2008	2011
Molecular and Cellular Biosciences	2008	2011
Emerging Frontiers	2006	2009
COMPUTER AND INFORMATION SCIENCE AND ENGINEERING		
Computing & Communication Foundations	2006	2009
Computer & Network Systems	2006	2009
Information & Intelligent Systems	2006	2009
EDUCATION AND HUMAN RESOURCES		
Research on Learning in Formal and Informal Settings		
Discovery Research K-12 (new in FY 2007)	N/A	2009
Informal Science Education	2008	2011
Information Technology Experiences for Students and Teachers (ITEST)	2008	2011
Research & Evaluation on Education in Science & Engineering (REESE)	2003	2009
Undergraduate Education		
Advanced Technological Education	2006	2009
Course, Curriculum, and Laboratory Improvement	2006	2009
Excellence Awards in Science & Engineering	N/A	2009
NOYCE Scholarships	2005	2009
Math and Science Partnership (MSP)	2008	2011
National SMETE Digital Library	2005	2009
STEM Talent Expansion Program (STEP)	2006	2009
Scholarships (S-STEM in FY 2007)	2007	2010
Scholarship for Service	2007	2010

Graduate Education		
GK-12 Fellows	2008	2011
Graduate Research Fellowships	2006	2009
Integrative Graduate Education and Research Traineeship Program (IGERT)	2008	2011
Human Resource Development		
Alliances for Graduate Education and the Professoriate	2007	2010
Centers for Research Excellence in Science and Technology	2007	2010
Gender Diversity in STEM Education	2006	2009
Historically Black Colleges and Universities – Undergraduate Program	2007	2010
Louis Stokes Alliances for Minority Participation	2007	2010
Program on Research in Disabilities	2006	2009
Tribal Colleges and Universities Program	2007	2010
ADVANCE Program	2008	2011
CAREER Program	2007	2010
ENGINEERING		
Chemical, Bioengineering, Environmental and Transport Systems	2006	2009
Civil, Mechanical and Manufacturing Innovation	2006	2009
Electrical, Communications and Cyber Systems	2008	2011
Engineering Education and Centers	2007	2010
Industrial Innovation and Partnerships	2007	2010
Emerging Frontiers in Research and Innovation (Created 10/1/06)	N/A	2010
GEOSCIENCES		
Atmospheric Sciences		
Lower Atmosphere Research Section	2007	2010
Upper Atmosphere Research Section	2008	2011
UCAR and Lower Atmospheric Facilities Oversight Section	2006	2009
Earth Sciences		
Instrumentation and Facilities	2007	2010
Surface Earth Processes Section		
Sedimentary Geology & Paleobiology	2008	2011
Geobiology and Low Temp Geochemistry	2008	2011
Geomorphology and Land Use Dynamics	2008	2011
Education and Human Resources	2007	2010
Deep Earth Processes Section	2008	2011
Ocean Sciences		
Integrative Programs Section		
Oceanographic Facilities	2008	2011
Oceanographic Instrumentation and Technical Service	2008	2011

GEOSCIENCES (continued)		
Ocean Education	2006	2009
Ship Operations	2008	2011
Marine Geosciences Section	2006	2009
Ocean Section	2006	2009
Other Programs		
Global Learning and Observation to Benefit the Environment	2007	2010
Opportunities for Enhancing Diversity in the Geosciences	2007	2010
Geoscience Education	2007	2010
Geoscience Teacher Training	2007	2010
MATH AND PHYSICAL SCIENCESS		
Astronomical Sciences	2008	2011
Chemistry	2007	2010
Materials Research	2008	2011
Mathematical Sciences	2007	2010
Physics	2006	2009
SOCIAL, BEHAVIORAL, AND ECONOMIC SCIENCES		
Science Resource Statistics (SRS)	2006	2009
Behavioral and Cognitive Sciences	2006	2009
Social and Economic Sciences	2007	2010
Science of Learning Centers	N/A	2009
Human and Social Dynamics	2008	N/A
OFFICE OF CYBERINFRASTRUCTURE	2008	2011
OFFICE OF INTEGRATIVE ACTIVITIES		
Experimental Program to Stimulate Competitive Research (EPSCoR)	2005	2009
Major Research Instrumentation (MRI)	2005	2010
OFFICE OF INTERNATIONAL SCIENCE & ENGINEERING	2008	2011
OFFICE OF POLAR PROGRAMS		
Polar Research Support	2004	2009
Antarctic Sciences	2006	2009
Arctic Sciences	2006	2009

Appendix D: Program Evaluations
D.2. External Evaluations

Following is a summary of the findings and recommendations of external evaluations of NSF programs published during Fiscal Year 2008. The evaluations are the results of workshops, studies, or reports commissioned by various programs in the National Science Foundation. The list is organized alphabetically by the NSF Directorate/Office that commissioned the evaluation, with evaluations commissioned by more than one Directorate/Office listed first.

<table>
<tr><td></td><td>Directorate for Engineering (ENG)
Directorate for Mathematics and Physical Sciences (MPS)</td></tr>
<tr><td>WTEC Workshop on Simulation-Based Engineering and Science

April 25, 2008</td><td>Findings:
Investment in algorithm, middleware, and software development lags investment in hardware, preventing the full exploitation utilization of new and even current architectures
Anticipated inability to fully exploit multicore/petaflop technology
Lack of support and reward for code development and maintenance
Timescale to develop large complex code is great, exceeding hardware lifetime
The UK, which once led in this, no longer provides support in this area
Progress in Simulation-Based Engineering and Science (SBE&S) requires crossing disciplinary boundaries
US perceived to be leaders in interdisciplinary teams
Best SBE&S students leaving science (e.g. Switzerland, computational scientists/engineers are being hired by financial sector)
Recommendations:
Industry-driven partnerships with universities, labs to hardwire scientific discovery to engineering innovation through SBE&S
Payoff: New and better products; development savings in cost and time
Developing standards for interoperability of codes
New paradigms for education and training of the next generation (software engineering, V&V, petascale, etc.)
Long-term support of code development (and maintenance) projects for targeted problems in science and engineering
Support to community in preparing for multicore/petascale
Availability: http://www.wtec.org/sbes/workshop/FinalWS-20080425/SBES-allpresentations-30Apr08-lowres.pdf</td></tr>
</table>

	Directorate for Engineering (ENG) **Directorate for Biological Sciences (BIO)**
Advancing Tissue Science and Engineering: A Multi-Agency Strategic Plan	**Scope:** Tissue science and engineering is dependent on a better understanding of subcellular biological pathways; this understanding in turn requires the availability of advanced technologies at the nanometer-, micrometer- and meso-scales. Tissue science and engineering applications will include medical therapeutics and highly innovative non-medical applications. As a result, it is appropriate to understand how tissue science and engineering contributes to or benefits from other Federal initiatives such as the National Nanotechnology Initiative, the National Institutes of Health (NIH) Roadmap, the FDA Critical Path Initiative, and the Medical Innovations Report. **Findings:** Leadership from the Federal agencies involved in tissue science engineering will be required if the United States is to: • Set the standards for the efficient and effective management of tissue science and engineering research and products • Maintain U.S. scientific and engineering preeminence in this field and ensure that the potential of this promising technology is fulfilled • Support the national research priority of developing a deeper understanding of complex biological systems, which requires collaborations among physical, computational, behavioral, social, and biological scientists and engineers • Capture the potential benefits to society from both medical and non-medical applications of tissue science and engineering **Recommendations:** ***Strategic Priority 1: Understanding the Cellular Machinery*** Obtain a molecular-level understanding of the physical, chemical, and biological conditions that direct cells to assemble into and maintain complex communities and functional 3D tissues. ***Strategic Priority 2: Identifying, Validating Biomarkers and Assays*** Identify biomarkers that can be used to specify cells in tissue-engineered constructs, assess their physiological state and/or condition such as their state of differentiation. Develop high-throughput, high-content assays for collecting multiparametric data and correlating that information with biologically significant outcomes. ***Strategic Priority 3: Advancing Imaging Technologies*** Develop high-resolution, non-destructive imaging technologies to assess

	engineered tissue function *in vivo* and *in vitro* in real time. ***Strategic Priority 4: Defining Cell/Environment Interactions*** Develop design principles for new materials based on a physical and quantitative understanding of how cells respond to molecular signals and integrate multiple inputs to generate a given response in their physiological environment. Test new matrices for biocompatibility and successful integration into relevant hosts or *in vitro* platforms. ***Strategic Priority 5: Establishing Computational Modeling Systems*** Make available user-friendly, predictive (physiological, biological, and mechanical) computational models whose simulations will aid in the engineering of reproducible tissue constructs. ***Strategic Priority 6: Assembling and Maintaining Complex Tissue*** Develop novel tools and bioreactors to precisely control rapid stem/progenitor cell expansion as well as the chemical and mechanical environment for phenotype-directed 3D tissue growth and function. ***Strategic Priority 7: Improving Tissue Preservation and Storage*** Optimize methods for long-term, low-cost, low-maintenance preservation that allow recovery of viable and functional cells/tissues. Develop better storage, shipping, and packaging techniques to provide tissues on demand. ***Strategic Priority 8: Facilitating Effective Applications Development and Commercialization*** Facilitate cost-effective production and scale-up of tissues and organs that can effectively meet regulatory requirements for good manufacturing practices and meet aggressive cost-benefit targets for a wide variety of applications. Availability: http://tissueengineering.gov/welcome-s.htm

	Directorate for Engineering (ENG) **Directorate for Biological Sciences (BIO)**
Report from the US-EC (European Commission) Workshop on Infrastructure Needs of Systems Biology	**Findings:** Systems biology is in a state of rapid development, characterized by an inability of the infrastructure to keep up with the demands of the science. **Recommendations:** Experimental Tools • Support the joint creation of common experimental protocols, selection of truly validated common cell types, tools for single cell analysis, globally useful reagents, reporter constructs, etc., thus making experimental data more valuable for modeling. • Make established experimental techniques broadly available to the community. • Create a large-scale proteomics effort which would include alternative modifications, localization, structure, etc. Databases • Establish criteria for long-term support for systems biology relevant databases. • Support the development of standard representations enabling interoperability between databases and tools. • Support data capture incorporating minimal information, using standard formats and semantics. • Support and broaden BioMart-like data integration schemes going beyond sequence centric approaches. • Promote access to full-length paper text and repositories and promote semantic enrichment efforts. • Support 'workflow' schemes in the context of systems biology. Models, Modeling, and Software • Support initiatives in multi-scale modeling spanning molecular to multi-tissue organism levels. • Support the use of standards and environments that permit interoperability and integration. • Initiate an infrastructure-related software support mechanism in the EC (like in the US). • Support systems biology software repositories which incorporate software curation. • Support education in the use of software within systems biology. Organization and Education • Support education in the use of software within systems biology. • Initiate US-EC collaboration on establishing curricula in systems biology. • Support activities similar to competitions like Internet Genetically

	Engineered Machine Competition (iGEM) (see www.igem2007.com). • Support community building around concrete projects, e.g., ontologies and databases, funded jointly by the US-EC. In effect international glue-grant funding. • Establish joint US-EC panels for assessment of research projects. • Joint US-EC systems biology benchmark studies such as A European Network of Excellence (ENFIN-DREAM) www.enfin.org/dokuwiki/doku.php?id=wiki:wp7 and http://magnet.c2b2.columbia.edu/news/DREAMInitiative.pdf). This could possibly include funding for pre- and post-prediction experimental data generation, evaluation, and creation of standards. • Generate procedure for US involvement in European Strategy Forum on Research Infrastructure (ESFRI). Specific Recommendations for Prompt Action • Create a mechanism to support ongoing joint US-EC benchmark efforts with special emphasis on data generation. • Start effort on standards and interoperability for databases, software, and experimental systems. • Exchange information on training programs. **Availability:** http://ec.europa.eu/research/biotechnology/ec-us/docs/us_ec_syst_biology_workshop.pdf

	Directorate for Engineering (ENG) Directorate for Biological Sciences (BIO)
U.S.-Europe Workshop on BioSensing & BioActuation: Interface of Living & Engineered Systems ***July 2008***	**Findings:** The NSF-ESF BioSensing and BioActuation Workshop, held June 15-17, 2008 in Taormina, Italy, brought together leading trans-national researchers, including 20 from the US and 35 from Europe, with a common interest in multi-disciplinary research on biologically inspired sensors, actuators and engineering systems. Program officers representing the ESF, NSF and AFOSR were present. Participants in the workshop discussed the current state-of-the-art in both the biology and engineering communities specifically highlighting the current needs, capabilities, grand challenges and collaborative opportunities surrounding biologically inspired sensors, actuators and engineering systems. The group was charged with developing a vision of the science and engineering research opportunities and revolutionary biosensing and bioactuation capabilities including formulation of the broader context and transformative advances gained through this cross-disciplinary US-European collaboration. Strong synergies for collaboration were found among the participants. Four major interdisciplinary research grand challenges were identified that will maximize the impact of the cross-disciplinary bio-derived and bio-inspired research initiatives and technologies envisioned by the workshop participants. The realization of these challenges will lead to fundamental new discovery and significant advances in science and engineering. **Recommendations:** • A compelling new research frontier exists in the basic science and engineering of biologically inspired sensors, actuators and engineering systems which will form the basis for revolutionary bio-derived and bio-inspired technologies. • Tremendous opportunities exist for synergistic ESF-NSF cooperative research on the transformational science and engineering pertaining to biologically inspired sensors, actuators and engineered systems including strengthening our basic understanding of these systems and societal outcomes derived from related technological advances for the environment, health, security and energy. • NSF and ESF should strengthen existing bonds and build new ties facilitating US Europe interactions, synergies and strengths by supporting this multi-disciplinary research initiative. • Financial resources to support these initiatives should be developed and committed. **Availability:** http://www.esf.org/research-areas/physical-and-engineering-sciences/us-europe-workshop-on-biosensing-and-bioactuation-interface-of-living-and-engineered-systems.html

	Directorate for Engineering (ENG) Directorate for Geosciences (GEO) Directorate for Social, Behavioral, and Economic Sciences (SBE)
Effectiveness of the National Earthquake Hazards Reduction Program: A Report from the Advisory Committee on Earthquake Hazards Reduction ***May, 2008***	**Findings:** While the Advisory Committee on Earthquake Hazards Reduction (ACEHR) was concerned about the limitations for funding for the National Earthquake Hazards Reduction Program (NEHRP), it found that NEHRP has achieved significant improvements, notably in its restructuring and broader collaborative efforts, since the 2004 reauthorization by Congress. NEHRP is committed to, and has made progress towards becoming a fully effective, collaborative, and focused program to protect the Nation against unacceptable risks from seismic hazards. NIST, as the newly designated lead agency for NEHRP, has formed a NEHRP office with a highly regarded director. Each of the other agencies including NSF has a significant role in NEHRP, with the active participation of each agency's director. NEHRP is responsible for ensuring earthquake risk reduction opportunities are made available to vulnerable communities. This responsibility ranges from conducting basic research to transferring research results into cost-effective mitigation. The overall success of NEHRP is highly dependant on legislative and administrative support for increased funding. To protect society against catastrophic earthquake-induced losses, NEHRP must become a well-recognized national priority. Risk reduction actions must be taken at the national, state, and local levels. This includes full funding of FEMA programs for the types of state-level programs that could lead to the creation of effective response plans to facilitate the immediate and long-term recovery process in the aftermath of a severe earthquake. In regard to the mission of NSF, fundamental research in earth science, engineering, and social science is critical to advancing our knowledge and should be fully supported in the context of NEHRP. It is equally critical to transfer research findings into practice. Without integrative research into the political, social, and economic circumstances that motivate society to achieve community resilience, implementation of proven earthquake resistant retrofit strategies will fall short. Sufficient attention is not being paid to the development of national standards for lifelines and existing buildings that will provide a resilient built environment. **Recommendations:** • NSF should enhance its support for multidisciplinary research related to NEHRP, which can be used as a model for reducing risks associated with other natural and human-induced hazards. In particular, there is an opportunity for the Engineering and

	Geosciences Directorate to partner with the Social, Behavioral, and Economic Sciences Directorate to understand the social and economic factors that promote mitigation measures • NSF should enhance its support for curiosity-driven basic research, which has been the foundation of many important technical discoveries. Basic research sponsored by NSF educates the next generation of engineers and scientists engaged in earthquake risk reduction. Such support is thus a means of expanding the workforce in earthquake engineering and science. **Availability**: http://www.nehrp.gov/pdf/2008ACEHRReport.pdf

	Directorate for Biological Sciences (BIO)
Where to Next with The Tree of Life? Workshop Report	**Scope:** To consider the nature of the tree of life, phylogenomics, horizontal gene transfer, and developmental evolution in the context of the Tree of Life program, and to provide perspectives on the future of the Tree of Life program. **Findings:** The Tree of Life program has had significant success in its first decade. Major branches have been explored and progress has been made in reconstructing the history of life. A number of areas, addressed in the Recommendations below, should be considered in the future of the program. **Recommendations:** A number of recommendations were made including: • Microbial diversity need broader representation on the tree of life. • Horizontal gene transfer is an important process that should be incorporated into tree of life research. • Better coordination between project teams will ensure that the phylogenetic information gathered by individual groups can be integrated into a comprehensive Tree of Life. **Availability**: Forthcoming

	Directorate for Biological Sciences (BIO)
2020 Vision for Biology: The Role of Plants in Addressing Grand Challenges in Biology	**Scope:** A group of scientists from the United States, Europe and South America discussed the progress of this program and charted the future directions for the field. **Findings:** The workshop participants concluded that during the last 20 years Arabidopsis has emerged as the primary experimental system for essentially all aspects of plant biology. By focusing on a single tractable system, the international Arabidopsis community has made dramatic advances in nearly every area of plant research. Further, because of the close evolutionary relationships between all flowering plants, discoveries in Arabidopsis have been readily translated to other plant species such as economically important crops. In addition, discoveries made in Arabidopsis have impacted research in animal systems including disease processes in human. The remarkable success of Arabidopsis research is partly the result of wise investment by the NSF, first through the Arabidopsis Genome sequencing program and attendant technology development and subsequently via the Arabidopsis 2010 Program. This project, now nearing its completion, has funded the generation of a broad range of powerful genetic and genomic resources and technologies. The Arabidopsis toolbox, together with the unique qualities of Arabidopsis and allied species, will now facilitate effective studies at all levels of biological organization including, molecular, cellular, organismal, and ecological. In addition, the Arabidopsis 2010 Program has fostered the development of a vigorous and dynamic international community of researchers, a process that has included the training of many graduate students and postdoctoral researchers, and recruited many scientists not trained initially in plant biology. Because of this investment, the Arabidopsis research community is ideally, and uniquely, positioned to address the Grand Challenges in biology as described below. A true systems biology approach, encompassing all of life's components from molecules to populations, is now possible using Arabidopsis. **Recommendations:** • Funding agencies should continue to provide major and specific support to integrate molecular, cellular, organismal, and ecological research on Arabidopsis as a system to understand how a living organism develops, functions and adapts to its environment. • Funds should be provided for development of additional and new types of large-scale experimental genomics resources that will be required to effectively address the Grand Challenges.

	• Efforts should be made to encourage the development of new quantitative approaches to the study of biological systems using Arabidopsis and allied species. This should involve the development of collaborations between biologists, mathematicians, computer scientists, engineers and scientists in other quantitative disciplines. • Data acquisition should remain a major focus of future programs to fuel iterative cycles of data analysis, integration, hypothesis generation and testing. The emergence of new technologies will enable the collection of new and higher quality data of all types, thus permitting more sophisticated systems analyses. Availability: http://arabidopsis.org/portals/masc/workshop2020.pdf A workshop summary was published by Natasha Raikhel in the journal Molecular Plant (http://mplant.oxfordjournals.org/cgi/content/full/1/4/561) *Reference: Mol Plant 2008 1: 561-563; doi:10.1093/mp/ssn040*

	Directorate for Education and Human Resources (EHR)
The Federal Cyber Service: Scholarship for Service (SFS) Program – Summative Evaluation Report ***Abt Associates January 2008***	**Scope**: This SFS final report is for a three-year evaluation of the SFS program conducted by the Assessment Services Branch of the Division for Human Resources Products and Services, U.S. Office of Personnel Management (OPM), for the National Science Foundation, Division of Undergraduate Education. The evaluation centers around the following questions: 1. How well is the SFS program delivered? Are the necessary supports established and effective? 2. How extensive is the demand for IA professionals in the Federal Government and what are the opportunities for graduates of the SFS programs? 3. How effective is the SFS program? 4. Have desired program effects occurred (e.g., high quality candidates, retention for 2 years in Government jobs)? **Findings**: Results of the third-year SFS program evaluation are encouraging. The overall finding suggest a generally well-implemented program with a number of clear successes in achieving important goals. Note that a comparison of results across multiple years also indicates improvement. Overall satisfaction with the program was high, according to 95 percent of PI/faculty survey and 84 percent of student respondents. Student Quality: More than two-thirds of SFS students had entry GPAs above 3.5, indicating that the program attracts high-quality students. Most supervisors of SFS interns/employees (89 percent) reported satisfaction with the overall quality of SFS graduates. Capacity Building: Most PIs agreed that the SFS program has improved their department's reputation (81 percent) and increased their department's visibility (96 percent). More than two-thirds of students were satisfied with the opportunity that internships provide for on-the-job training and to apply classroom learning. Most SFS graduates agreed that mentoring had contributed to their job-career success (72 percent) and likelihood of remaining in the information security field (71 percent). Placement and Retention: As of September 2007, the cumulative job

	placement for graduates was at 88 percent. Survey results for SFS graduates indicate that 74 percent are still working in the same Federal agency in which they began to fulfill their employment obligations. Other notable findings are that the funding of the program is sufficient and distributed fairly, focus groups and survey results indicate that some universities have adopted best practices in preparing SFS students, and continue to adhere to the current undergraduate and graduate stipend levels. **Recommendations**: Within the evaluation, recommendations are made under the following areas: Marketing: Leverage the SFS website more effectively to inform agencies of program benefits. Agency representatives could be directed to the SFS website via announcements on Federal IA subscription electronic mailing lists and advertisements in Federal IA publications. Administration: NSF needs to modify the program solicitation to maximize the percentage for management and administrative costs from 15 percent to 20 percent, and to include a requirement for an external evaluator to assess program outcomes. OPM and NSF need to clarify the SFS contract regarding the responsibilities of students. OPM needs to develop a manual outlining all the rules, regulation and expectations of the program. **Availability**: United States Office of Personnel Management (OPM). (2008). *Summative Evaluation Report: The Federal Cyber Service: Scholarship for Service Program.* Washington, DC: OPM Division of Human Resources Products and Services.

	Directorate for Education and Human Resources (EHR)
Evaluation of the Faculty Early Career Development (CAREER) Program: Final Report ***Abt Associates*** ***June 2008***	**Scope**: This study assesses the longer-term impacts of a CAREER award on awardee's professional advancement, research productivity, and engagement in integration. The evaluation was designed to answer four questions: 1. How do stakeholders at NSF perceive the CAREER program and its relationship to the mission of NSF? 2. What is the impact of CAREER on the research activities and career advancement of awardees? 3. What is the impact of CAREER on the integration of research and education by awardees? 4. How do faculty members in department that host CAREER awardee(s) view the CAREER program and its relationship to their research and education missions? **Findings**: 1. The majority of the NSF program officers interviewed describe the CAREER program as a highly successful effort to support the early careers of STEM faculty members. A small minority of program officers commented that the structure of the CAREER program was misaligned with the mission of research in disciplines where new researchers do not have significant educational responsibilities. 2. The most common reasons cited by active CAREER awardees for applying to the CAREER program were CAREER's importance in tenure review (78 percent) and CAREER's prestige (66 percent). All CAREER awardees report positive benefits from their CAREER award for their own professional development (98 percent), with 50 percent valuing the opportunity to pursue new research topics. 3. Sixty percent of active CAREER awardees cited alignment between CAREER's emphasis on integrating research and education and their own goals as one of the reasons they applied for CAREER funding. Additionally, forty three percent of awardees noted that CAREER provided them with an opportunity to pursue an educational activity that subsequently benefited their research. 4. Though CAREER awardees are the direct beneficiaries of the Faculty Early Career Development Program, departments

	may also derive benefit from the presence of awardees. Having a CAREER awardee on faculty might enhance the prestige of the department and encourage other junior faculty to apply. This evaluation suggests that the presence of CAREER awardees in a department has a far stronger impact on the research side of the university culture than on the education and integration side. While having a CAREER award is not a requirement for tenure, 93 percent of department chairs agreed that winning a CAREER serves as an important factor in the promotion process; the CAREER award is viewed as an external endorsement of the quality of the PI's research. 5. Sixty-two percent indicated that tenure review committee members had specifically mentioned the CAREER grant as a positive factor in the decision process. 6. Winning a CAREER award does not increase time that awardees spend on education, but awardees report that it did change their interest in or focus on educational activities. **Questions for Further Study**: 1. Should PECASE awardees be selected solely from among CAREER awardees? 2. Should the minimum award size be set agency-wide or allowed to vary among individual directorates? 3. Is it sufficient for awardees (and by extension, their institutions) to "integrate" research and education by pursuing excellence in each domain separately, or must awardees pursue a unified research and education agenda in which these two domains are interdependent, such that the activities in one could not advance without activities in the other domain? 4. At what level(s) – graduate, undergraduate, or K-12 – should awardees be targeting the development of integrated research and education agendas? 5. What activities count as integration of research and education? 6. How accountable should CAREER awardees be for conducting and reporting to NSF on the outcomes of their proposed education and integration activities? **Availability**: Carney, J., Smith, W., Parsad, A., Johnston, K. and Millsap, M. (2008). *Evaluation of the Faculty Early Career Development (CAREER) Program.* Bethesda, MD: Abt Associates, Inc.

	Directorate for Education and Human Resources (EHR)
Evaluation of the Teacher Professional Continuum: Final Report ***Abt Associates October 31, 2008***	**Scope**: In 2005, NSF contracted with Abt Associates to perform an evaluation of the portfolio of projects funded by the TPC program. The evaluation was understood to be focused on the portfolio's success in implementing the major foci in the solicitations from FY03 through FY05. Among the study questions the evaluation was designed to answer were the following: 1. How are the TPC resources allocated? 2. What are the characteristics of the TPC portfolio? 3. How successful has the TPC portfolio of grantees been in meeting the goals of the TPC program? 4. What have been some of the challenges or barriers in addressing the program goals? How have the projects overcome barriers or challenges? 5. What have been some of the facilitating factors in addressing the program goals? 6. To what extent has the TPC program shifted the focus of the field from practice to research? The Abt Report notes on Page V of the Executive Summary: "Given that most of the research and resource projects on which this evaluation focuses are still in progress, a challenge was assessing outcomes, products, and contributions of the projects based on information provided in projects' reports to NSF. Few of the four-year studies and none of the five-year studies funded in 2003 (the first funding year) had submitted final reports by the Fall of 2007 when the final set of data were collected for this evaluation." Based on an analysis of the program goals, using 121 projects, stated in the TPC solicitations, Abt Associates constructed unified statements on the program's primary goals and elaborated indicators for them. The seven goals upon which the TPC program was evaluated (and on which findings and conclusions are later enunciated) are: 1. Advancing the knowledge base on the recruitment, preparation, induction, enhancement, and retention of STEM teachers, and on strategies that strengthen and diversify the STEM teaching workforce. 2. Promoting scientifically based research that examines teacher learning of STEM content and pedagogy, and

	assesses the subsequent impact of this learning on practice. 3. Encouraging research on effective professional development models and experiences that enhance STEM teachers' pedagogical content knowledge and its alignment with classroom practice. 4. Understanding, through research, those instructional practices that enhance student learning in STEM disciplines. 5. Developing innovative resources, materials, tools, and ideas, for preparing and supporting STEM teachers and those who educate them. 6. Fostering effective collaborations between the communities of STEM K-12 teachers, STEM researchers, practitioners, and others contributing to STEM education. 7. Disseminating research findings, effective models, and field-tested resources to national audiences of practitioners, administrators, researchers, policy makers, education faculty, and STEM disciplinary faculty. **Findings**: The following conclusions can be drawn about the success of the TPC program in achieving the seven goals enumerated above: Goal 1: The portfolio of TPC projects is contributing to confirming and strengthening the knowledge base on teacher preparation and enhancement in mathematics and science. More than half of the research activity targeted middle and high school mathematics and science. Additionally, 61 percent of the projects focused on teaching pedagogy. Goal 2: The TPC program was successful in funding a large number of research and research-intensive resource projects to conduct scientifically based research that examines teacher learning of STEM content and pedagogy. Specifically, 77 percent of the 58 research projects and all 11 of the research-intensive resource projects asked at least one research question about the impact of an intervention on teacher and student outcomes. Goal 3: A number of projects used different professional development models in their research and strove to enhance teachers' pedagogical content knowledge, and study its alignment to classroom practice. Goal 4: Approximately half the projects in the TPC portfolio intended to measure student outcomes. Given that project interventions can first be expected to influence teachers before they

	influence students, it is likely that some projects will produce results related to student outcomes as they get closer to completion. Goal 5: The program was successful in encouraging resource projects to produce a wide range of resources for teachers and other education professionals using a variety of media. The majority (89 percent) of the resource projects created materials and resources for teachers and almost one-third (30 percent) targeted professional development providers. Goal 6: The program was successful in encouraging the majority of TPC projects to establish partnerships and collaborations with individuals and organizations with which they had not worked before. The types of organizations that projects most commonly cited as partners or collaborators were school districts, schools, college/university departments and centers, and research organizations. Goal 7: Although many TPC projects are still in the early stages of project work, approximately one-third has been active in disseminating information about their work to a wide variety of audiences. Yet, it is reasonable to expect that as TPC projects mature and produce research-based and evaluation outcomes, they will disseminate results that contribute to advancing the knowledge base. **Recommendations**: Goal 1: Projects' peer-reviewed publications be reviewed, as journal articles are the primary vehicle for sharing project results and the methods employed to achieve the results. Goal 2: Develop/provide the projects/reviewers with summary guides that list the conditions that different types of designs and analyses must meet to be considered rigorous. Have projects map their research questions to their designs and analyses in a summary table. Commission a project to review and compile existing research instruments, assess their reliability and validity, cite studies in which they have been used, and make results available on a dynamic, easily updateable website. Goal 3: Studies be funded that are designed specifically to assess the efficacy of different models in enhancing all three components of pedagogical content knowledge.

	Goal 4: Have a competition for, or commission studies, that are designed specifically to assess the impact of fully implemented teacher professional development activities on student outcomes. Goal 5: Assess the efficacy of the resources that were developed, by: the degree to which they are used and adopted; and the impact they have on their target audience. Goal 6: Define *partnership, collaboration, and contact* in its annual report form to ensure that PIs respond to the items as intended. Provide more specific guidelines to PIs about where in their annual reports it wants PIs to discuss their collaborations and the type of information it wants PIs to provide about the nature and effectiveness of the collaboration. **Availability**: Lovitts, B., Bobronnikov, E., Breaux, G. and Lauman, B. (2008). *Evaluation of the Teacher Professional Continuum Program Portfolio*. Bethesda, MD: Abt Associates, Inc.

	Directorate for Engineering (ENG)
Workshop: Healthcare Engineering and Health Services Research: Building Bridges, Breaking Barriers	**Findings:** Few would dispute that the rapidly escalating cost of health care is one of the most pressing issues facing our nation today. Even a cursory review of the media reveals intense public concern over a healthcare system that can use the most advanced technology to miraculous therapeutic effect, but whose emergent behavior is far from ideal. Rapidly rising healthcare costs threaten the competitiveness of U. S. manufacturing and service companies in the global economy, creating intense pressure to move offshore. Indeed one can make the case that the best way to help competitiveness prospects for U. S. industries, as a whole is to improve healthcare delivery. **Recommendations:** • The National Science Foundation (NSF) should adopt the application of science and engineering to improving the healthcare delivery system as one of its missions, representing and supporting the engineering community in its efforts to contribute to what is possibly the most important societal problem of our time. • NSF should create interdisciplinary engineering and science initiatives that complement current "translational research programs" in the NIH and "evidence-based programs" in AHRQ. • NSF should encourage doctoral students, post-doctoral students, and junior faculty to take up careers in this area by providing Graduate Fellowships and early career funding. • NSF should direct substantial research in the behavioral sciences towards understanding the problems of effective collaboration between scientific, engineering, clinical and health services disciplines. • NSF should reach out to other government agencies such as the Veteran's Administration, the Department of Defense, and the National Institutes of Health to establish a long-term, interdisciplinary funding program directed explicitly at the healthcare delivery system. • NSF should provide funding opportunities for engineering schools to develop long-term collaborative relationships with academic medical centers (such as the Veteran's Administration) to form a living laboratory for the multidisciplinary study of problems of importance to national health policy that extend systems engineering methodology. • As part of its funding opportunities NSF should encourage the study of international health systems and collaboration with international investigators to develop sound options for a health care delivery system design in the U.S. **Availability:** http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1068&context=rche_rp

	Directorate for Engineering (ENG)
Research Experiences for Undergraduates (REU) in the Directorate for Engineering (ENG): 2003-2006 Participant Survey ***A Draft Report to the National Science Foundation*** ***SRI International, August 2008***	**Scope:** ENG has two major award types for REUs -Site and Supplement awards. ENG wanted a comparison of REU Sites funded by the Division of Engineering Education and Centers ("EEC Sites"), REU Supplements funded by Engineering Research Centers ("ERC Supplements"), and REU Supplements funded by other divisions within ENG ("ENG Supplements"). In addition, ENG wanted the study to assess differences among respondent groups (undergraduates and faculty mentors) and, for undergraduates, differences by sex and race/ethnicity. The study is being conducted through two surveys. This report describes the initial survey of faculty and undergraduate participants in all EEC Sites and ERC Supplements during FY 2003 through FY 2006 and ENG Supplements during FY 2006, which was conducted during fall 2007. A follow-up survey of the FY 2006 undergraduate participants is planned for fall 2009 to measure the longer-term impact of their REU experiences. The initial survey focused primarily on specific REU experiences during the summer or the academic year but also asked about other undergraduate research experiences and about academic and career decisions. The follow-up survey will cover all undergraduate research experiences, as well as academic and career decisions. **Findings:** Research experiences for undergraduates had a variety of significantly positive effects on the undergraduates who participated in them, including gains in awareness, confidence, skills, and understanding; increased interest in related careers; and raised academic expectations. There were only slight differences in gains in awareness, confidence, skills, and understanding and no differences in increased interest in related careers or raised degree expectations across the three award types. Among the several racial/ethnic groups, Hispanics were the most likely to report these various positive effects. There were no reliable differences in effects between men and women. Undergraduates who were motivated to participate in research because they wanted help with career decisions, had enthusiasm for research, or had prior personal contact with researchers showed the highest gains in awareness, confidence, skills, and understanding. Those involved in a variety of research-related activities, who had adequate time with a research mentor, and who gained increasing independence over the course of the research also showed higher gains in these areas. Undergraduates who indicated a higher increase in confidence and awareness as a result of their research experiences also showed increased interest in a career in engineering or research and were more likely to obtain a PhD.

	Recommendations: To come after completion of follow-up survey of the FY2006 undergraduate participates in fall 2009 which will measure the longer-term impact of the participants REU experiences. **Availability:** http://www.sri.com/policy/csted/reports/university/

	Directorate for Geosciences (GEO)
NSF Workshop: Community Sedimentary Model for Carbonate Systems ***February 2008***	**Scope:** An NSF-sponsored workshop on carbonate systems and numerical systems modeling was held in late February, 2008, at the Colorado School of Mines. The purposes of the workshop were to identify grand challenges for fundamental research on ancient and recent carbonate systems, and to identify promising areas for advancing the next generation of numerical process models to enhance our ability to meaningfully and accurately model carbonate systems. Developing predictive models of carbonate systems has important implications for monitoring and managing global climate change affecting societies around the world. Carbonate sediments and rocks form an important part of the global carbon cycle. More than 80% of Earth's carbon is locked up in carbonate rocks. Almost all of the remainder is in the form of organic carbon in sediments. About 0.05% of Earth's carbon is present in the ocean in the form of the carbonate and bicarbonate ions and dissolved organic compounds, whereas 0.0008% is tied up in living organisms, and about 0.002% is in the form of CO_2 in the atmosphere. Carbonate rock is the primary ultimate sink for CO_2 introduced into the atmosphere. **Findings:** Short- and long-term goals were identified for five areas. 1. Physical controls on carbonate deposition. 2. Biological controls on carbonate deposition. 3. Diagenesis. 4. Numerical modeling strategies. 5. Tools needs and development. **Recommendations:** The grand research challenges for advancing understanding of modern and ancient carbonate systems identified in this first integrated community workshop include: 1) Quantitatively understanding and modeling facies heterogeneities developed over various timescales, as influenced by changing biotic, paleoceanographic, paleoclimatic, and sea level conditions; 2) understanding the appropriateness of using Holocene tropical shallow-water reefs as analogues for ancient carbonate buildups; 3) developing predictive numerical simulations of diagenetic history from the scale of the pore to the scale of the platform by incorporating and coupling sedimentation, chemical and biological alterations on the seafloor, mechanical overprints, and chemical alterations resulting from fluid flow;

	4) resolving cyclostratigraphy to the 0.02-0.4 my level using high resolution biostratigraphy and absolute age dates; A more coordinated research effort in carbonate systems would be beneficial to advancing these community challenges. The group recommended research that focuses on identifying a limited number of sites to conduct integrated research on selected key subsets of: (1) the modern to Pleistocene, to examine the effects of ocean conditions and climate change on carbonate sedimentation, and the evolution of sediments into beds and strata; and (2) important analog field areas that combine outcrop, behind outcrop, and the subsurface, to build a new generation of 3-D carbonate system models. **Availability:** http://csdms.colorado.edu/meetings/carbonates_2008.html

	Directorate for Geosciences (GEO)
Origin and Evolution of Earth: Research Questions for a Changing Planet	**Scope:** At the request of the DOE, NSF, USGS, and NASA, the National Academies established a committee to propose and explore grand Earth science questions being pursued today. The research questions cover a variety of spatial scales and temporal scales, from subatomic to planetary and from the past (billions of years) to the present and beyond. **Findings:** Ten grand research questions are identified and discussed. 1. How did Earth and other planets form? 2. What happened during Earth's "dark age" (the first 500 million years)? 3. How did life begin? 4. How does Earth's interior work, and how does it affect the surface? 5. Why does Earth have plate tectonics and continents? 6. How are Earth processes controlled by material properties? 7. What causes climate to change – and how much can it change? 8. How has life shaped Earth – and how has Earth shaped life? 9. Can earthquakes, volcanic eruptions, and their consequences be predicted? 10. How do fluid flow and transport affect the human environment? **Availability:** DePaolo, D.J., et al., Origin and Evolution of Earth: Research Questions for a Changing Planet, National Academies Press, 137 p., 2008.

	Directorate for Geosciences (GEO)
Comparative Analysis Of Marine Ecosystem Organization (CAMEO): Advancing Fundamental Understanding of Marine Ecosystem Processes as a Foundation for Living Resource and Habitat Management A Prospectus	**Findings:** A conceptual framework for comparative analysis of marine ecosystems involves selecting appropriate ecosystem types that are comparable in terms of structure and function, drivers of change and variability, and characterization of socially relevant properties of ecosystems. The scientific challenge for CAMEO is to use comparative analysis of marine ecosystems in innovative ways in concert with experimental, modeling and data assimilation approaches to elucidate: • How the provision of goods and services by ecosystems with different characteristics responds to natural and anthropogenic pressures and drivers of change; • Limits to ecosystem resilience, and thresholds that, when crossed, lead to phase or regime shifts, and the nature of reversibility of such shifts; • Relative performance of different management "treatments" (such as marine protected areas) by comparing similar ecosystems or sub-ecosystems subjected to different treatments; • Relationships between the human dimension of ecosystems, drivers of change, and the willingness and ability to apply management alternatives; and • Ways of translating scientific knowledge into scientifically based decision support tools that policy makers and managers need and will use. **Recommendations:** Initial priorities • Development of strategies and methodologies for comparative analyses, including modeling frameworks that can be applied consistently across ecosystems, and that facilitate design of decision support tools. • Modeling studies focused on specific concepts, such as connectivity, resilience or thresholds. • Retrospective studies that analyze or re-analyze or synthesize existing information (historic, time-series, ongoing programs, etc.) using a comparative approach. • Short-term empirical studies based around existing or proposed observation systems designed to "demonstrate" how such a system could be leveraged towards ongoing comparisons. • Short-term pilot projects to allow groups of investigators to organize and design larger programs. Agency action • Workshops to further develop aspects of human dimensions in comparative analyses, harmonizing social science and natural science approaches and concepts, and to foster formation of interdisciplinary research teams;

	• Establishment of a CAMEO program office and scientific steering committee to oversee the program, guide preparation of a “grand strategy” for comparative analyses, and synthesize program results across projects. **Availability:** http://cameo.noaa.gov/documents/CAMEO_prospectus_FINAL_020408.pdf

	Directorate for Geosciences (GEO)
NSF/NIEHS Centers for Oceans and Human Health and the NOAA Oceans and Human Health Initiative, Joint Annual Meeting, April 16-18, 2008	**Scope**: The report highlights research accomplishments and discussions for the future in the cooperative Oceans and Human Health programs (started in 2004) of the three agencies. **Findings:** Discussions and formal presentations at the meeting concerned the accomplishments of the OHH program and the identification of problems and issues that remain to be resolved. The eight presentations include discussions of the implications of climate change for human health and the impact of climate change on the oceans. They continue with a summary of the integrated ocean observing system and some examples of the use of ocean observations to safeguard human health. The conundrums of identifying suitable indicator organisms and associated monitoring strategies to ensure that coastal waters are safe for recreational use are outlined. Scientists present a progress report on the development of a high-throughput antibody-based assay for the detection of toxins in fish and shellfish. Finally, discusses research issues and problems are discussed that in the future may warrant greater emphasis in the OHH program. One of the important accomplishments of the OHH program has been the synergistic collaboration of scientists within centers and between centers. The result has been considerable leveraging of the funding to the centers and a scientific output that exceeds in important respects the results of traditional grants to individual investigators. Examples of this scientific synergism have included, inter alia, a textbook on Oceans and Human Health and a collaborative study of the impact of Hurricane Katrina on water quality in Lake Pontchartrain. These proceedings provide a good sense of the accomplishments of the OHH program and of the challenges and opportunities of the interdisciplinary science of oceans and human health. **Recommendations:** No over-arching recommendations beyond those in the various report chapters. **Availability:** http://www.prcmb.hawaii.edu/ohh2008.final.high.pdf

	Directorate for Geosciences (GEO)
External Review of the R2K Program	**Scope:** The NSF convened a panel of experts to consider the accomplishments of the R2K program to date and the future of R2K in its culminating few years. **Findings:** The accomplishments and trajectory of the RIDGE 2000 (R2K) program have been excellent. The program has achieved the following major goals: - Carried out comprehensive multi-disciplinary studies at two Integrated Studies Sites (ISS) with work on the third site (Lau Basin) well established. - Made time-series measurements of seismicity, hydrothermal flow, fluid composition and biological systems at the ISS. - Mounted rapid response expeditions which enabled observation of the recovery of physical and biological systems after singular events. - Established accessible data repositories for considerable cruise information - Developed an effective outreach program to scientists and the public. **Recommendations:** - The program must ensure that it achieves its original objectives of integrating and synthesizing its observations to model the wide-ranging interactions at mid-ocean ridges. - These synthesis objectives must become the highest priority during the remaining years of R2K, preparing for the planned end of the program in 2012. This work should take precedence over, and provide the justification for, any new field studies. - The planned field work scheduled for the Lau basin ISS is a high priority, and additional studies may be justified. However, it is important at Lau to begin fostering integration and synthesis of data to entrain the modeling community as soon as possible - It is unlikely that there is sufficient time and resources in the R2K program to permit development of a full new ISS at the Mid-Atlantic Ridge. The need for any new field studies should be evaluated carefully against the priority for modeling studies for integrating and synthesizing existing data. - The excellent web-based data repository generated by the program needs to be extended to include all the data, particularly fluid chemistry and biological data. R2K should ensure that the office and Steering Committee are appropriately staffed to achieve the integration and synthesis goals in the final part of the program. **Availability:** http://www.ridge2000.org/science/program_review_2008/panel_rec.html

	Directorate for Math and Physical Sciences (MPS)
2008 Annual Report of the Astronomy and Astrophysics Advisory Committee (AAAC) ***March 2008***	**Scope:** The AAAC advises the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the U.S. Department of Energy (DOE) on selected issues within the fields of astronomy and astrophysics that are of mutual interest and concern to the agencies. Astronomy and astrophysics are understood to encompass observations and theoretical investigations of astronomical objects and phenomena, including the sun and solar-system bodies. Specifically, the AAAC is charged to: Assess and make recommendations regarding the coordination of astronomy and astrophysics programs of the NSF, NASA and DOE. This includes the identification of gaps and duplications among the agencies in areas such as research, analysis programs, missions, observatories, facilities and archives. Assess and make recommendations on the status of NSF, NASA and DOE activities as they relate to the recommendations contained in National Research Council reports, especially the 2001 report "Astronomy and Astrophysics in the New Millennium." **Findings:** The AAAC's findings and recommendations for the agencies from the March 2008 are summarized below and discussed in detail in the report. **Recommendations:** The AAAC's strongest recommendation this year was that the goals of ACI and America COMPETES be realized for the NSF and the DOE Office of Science, and that the NASA science funding be enhanced, in accord with America COMPETES. The AAAC welcomed the continuing interest and support of Congress for the astronomical research program at NASA, NSF and DOE, but hopes that representations from individuals or groups for projects of interest to the petitioners do not lead to directives or earmarks that distort the astronomy community's strategic, consensus-driven priorities. The experience gained by the AAAC in helping to implement the recommendations of the 2000 Decadal Survey is represented in its Task Force reports and its Annual Report. The AAAC encouraged the agencies to discuss the AAAC Task Force reports and the AAAC Annual Report in their interactions with the Survey Committee and its Panels, as the AAAC

	plans to do when it meets with the 2010 Decadal Survey Chair. Given the uncompleted queue from the 2000 Decadal Survey, the AAAC feels that it is essential that *all* projects not under construction be considered again (e.g., GSMT, LSST, Con-X, LISA, SIM, etc.). The AAAC strongly encouraged the agencies and the NRC to build on the success of the BEPAC process, which used, in addition to scientific excellence, independent assessments of technical readiness and lifecycle cost to develop its recommendations and hoped that this approach will be a model for the next Decadal Survey. The AAAC also identified and commented on a number of programs that present particular opportunities and/or raise issues for the vitality of the nation's astronomy and astrophysics enterprise as carried out by NSF, NASA and DOE within the framework of the astronomy and astrophysics 2000 Decadal Survey and similar NRC reports and discussed specific programs and activities that involve interagency coordination. **Availability:** http://www.nsf.gov/mps/ast/aaac/reports/annual/aaac_2008_report.pdf

	Directorate for Math and Physical Sciences (MPS)
The National Science Foundation's Materials Research Science and Engineering Centers Program: Looking Back, Moving Forward	**Scope:** The Materials Research Science and Engineering Centers (MRSEC) Impact Assessment Committee was charged to examine the impact of the MRSEC program from its inception over ten years ago. **Conclusions:** 1) MRSEC center awards continue to be in great demand. The intense competition within the community for them indicates a strong perceived value. These motivations include: • The ability to pursue interdisciplinary, collaborative research; • The resources to provide an interdisciplinary training experience for the future scientific and technical workforce from undergraduate to postdoctoral researchers; • Block funding at levels that enable more rapid response to new ideas, and that support higher-risk projects, than is possible with single-investigator grants; • The leverage and motivation MRSECs provide in producing increased institutional, local, and/or state support for materials research; • The perceived distinction that the presence of a MRSEC gives to the materials research enterprise of an institution, thus attracting more quality students and junior faculty; and • The infrastructure that MRSECs can provide to organize and manage facilities and educational and industrial outreach. 2) The committee examined the performance and impact of MRSEC activities over the past decade in the areas of research, facilities, education and outreach, and industrial collaboration and technology transfer. The MRSEC program has had important impacts of the same high standard of quality as those of other multi-investigator or individual-investigator programs. Although the committee was largely unable to attribute observed impacts uniquely to the MRSEC program, MRSECs generally mobilize efforts that would not have occurred otherwise. 3) The effectiveness of MRSECs has been reduced in recent years by increasing requirements without a commensurate increase in resources. Increasing the mean grant size is necessary to allow the program to fulfill its important mission goals. 4) NSF encourages MRSECs to operate as a national network. Although some efforts have been made in that direction, the committee did not observe strong cooperation among the discrete centers of the program. The MRSEC program is thus missing a clear opportunity to leverage resources and thereby strengthen the materials-research enterprise as a whole.

	Recommendations: To respond to changes in the budgetary landscape and changes in the nature of materials research in the coming decade, NSF should restructure the MRSEC program to allow more efficient use and leveraging of resources. The new program should fully invest in centers of excellence as well as in stand-alone teams of researchers. **Availability:** http://www.nap.edu/catalog.php?record_id=11966

	Office of Cyberinfrastructure (OCI)
NSF International Research Network Connections Program ***January 2008***	**Scope:** The workshop attempted to answer the following question: What infrastructure will be required to support international collaborative science in the year 2010 and beyond? Scientists and researchers from a wide range of disciplines and domains were invited to present. A formal report on the workshop has been submitted to NSF and a link to the report is provided at the end of this document. **Findings:** Some surprising findings from the scientific presentations and international collaborations given at the workshop and International meetings included how dependent International Science is on the network connections provided by the IRNC program and how most of the scientists and researchers had no knowledge of the NSF IRNC program. While this is a testament to the success of the program (enabling international collaboration and research) it is also troubling as the value of the program does not seem to be adequately recognized which may lead to inadequate funding. At the same time, it is abundantly clear that the IRNC program is highly valued and recognized internationally, and has leveraged and obtained enormous support and resources far beyond the NSF contributions. The IRNC program is a critical element of U.S. international science policy and a core component of NSF's support of international Cyberinfrastructure. The IRNC program must not only be continued, but it needs to be significantly expanded and enhanced to support the next generation of scientific collaborations. Without expansion, the U.S. will lose ground and credibility in scientific discovery and international partnerships. **Recommendations:** The recommendations below are aimed at ensuring US leadership and collaboration in the international science community on issues of global importance, and thereby transforming US research and education in the future decades. **Extend Strategic Position and Leverage:** 1. Additional funding must be provided to maintain and extend the current US leadership and strategic positioning in networking to the entire world as well as being able to leverage funding and contributions from other nations. This is particularly true in light of the increasing investments by other countries in links that bypass the U.S. In discussion of the current IRNC projects it was clear that the program has done a remarkable job of leveraging the government investments. Leverage factors have multiplied

the value of every federal dollar beyond any reasonable expectation. In summary, the IRNC program has invested $24.3M over the last 5 years in international connectivity; foreign investments supporting the IRNC infrastructure is estimated to be $246M to $360M – a 10:1 or 15:1 ratio. Without that leverage, the U.S. would be even further behind in international research networking.

Programmatic Strategies

2. **Create Programmatic Flexibility:** The IRNC program should provide for "opportunistic" proposals that take advantage of unique moments in time. These include enabling investment in new commercial fiber optic cable projects at the time they are being developed when the costs are lowest and partnering with other international initiatives (e.g., TEIN3, or the new fiber builds taking place in Africa) as they are rolled out. The current 5-yr funding cycle does not maximize flexibility, and this will be even more important in the future to maximize leverage of U.S. investments.
3. **Encourage Partnerships with International Connection Programs:** The IRNC program should encourage the development and coupling of international connection funding programs from other countries such as the EU, Japan, China and so forth. This may also include more coordination with international projects such as GLIF and include funding of people and travel.
4. **Continue Dual Track Strategy:** The IRNC program should continue to simultaneously support "production" research networking and research network R&D. The two components benefit from integration at the individual project and investigator level. It may be worth exploring the availability or feasibility of multiple lambdas or even dark fiber for some of the international connections. Other components to be addressed include best-effort IP networks, IPv6, international multicast and hybrid networks and end-to-end connections programs. The need for peering across multiple international domains at line speed is important.

Programmatic Activities

5. **Broaden Programmatic Activities:** IRNC cannot just be about network connectivity; it needs to address higher levels in the network stack as well as the larger world of cyberinfrastructure; this includes attitude, people connections, exchanging knowledge and expertise, working together globally and virtually. This may include the need to create more “hubs” for international collaborations (like PRAGMA) where people and technology from various countries can come together.
6. **Orchestrate Interactions among International Collaborators:** The next instantiation of the IRNC program should have a component that focuses on creating a structure that will facilitate regular and frequent interaction between international collaborators, especially across domains. This will increase sharing and reduce duplicative and reinvention of software, tools and applications. The Workshop Organizers believe that greater national and international coordination would be useful in maximizing the value and utility of international cyberinfrastructure and networking investments. This needs to take place across disciplines (e.g.,

	multiple NSF Directorates, agencies (including science agencies outside the U.S.), research methodologies (e.g., networking, data, computation, and visualization) and nations. 7. **Address Needs of End-to-End Support and Training:** As the importance of international collaboration continues to grow, the IRNC program should also address the need for end-to-end support and last mile services. Another aspect includes the need for more training and education, especially as scientists move up power and capability curves to conduct their science. 8. **Leverage Regional Programs:** Geographic realities suggest that international networking programs address domestic issues as well. The work of WHREN with Puerto Rico is one example, and that of TLPW with Hawaii is another. The IRNC program should leverage these opportunities and identify opportunities for domestic co-funding (e.g., EPSCoR) where appropriate. 9. **Interconnect Major Scientific Instruments:** It is clear that a more formal effort should be undertaken to interconnect all the major scientific instruments across the globe. However, this is outside the purview of the IRNC program itself. The IRNC program could play a role in encouraging appropriate domains and disciplines to partner or participate in specific IRNC awards. For example, through a more formal partnership with the Astronomy directorate, as well as with sister programs in the EU, Japan, China and so forth, the Astronomy community might be able to leverage some of the IRNC infrastructure to help connect all the telescopes to high speed networks so they can be shared globally. This includes some early planning for projects like the Square Kilometer Array (SKA) which will have enormous data and transmission requirements. 10. **Address Network and Cyberinfrastructure Security:** Network and cyberinfrastructure security should be more explicitly addressed in the next version of the IRNC program – perhaps through specific out-of-band awards or as subprojects within the program. This includes encouraging policies and processes which support and enable international agreements and help develop an environment of trust to support collaboration science. 11. **Develop Tools and Standards for Collaboration:** Development of more easy-to-use tools for collaboration and support, especially support of international data standards, metadata generation, provenance and storage would be useful. This is especially important as the global network of instruments will increase by a factor of at least a 1,000 over the next 3 years. Data capacity and compute capability will increase by a factor of 500. Development of standards will require activity partnerships with other directorates at NSF and their communities. 12. **Extend Connections to All Countries:** Encourage deeper and wider international collaborations with scientists from every continent; some targeted efforts and funding for third world countries and science similar to the EPSCoR program NSF supports domestically. This should probably include a partnership and joint program with multiple directorates working with OISE and OCI to address international cyberinfrastructure issues and develop new capabilities. Availability: http://www.renci.org/publications/irncworkshop.php

	Office of Cyberinfrastructure (OCI)
Building Effective Virtual Organizations ***January 2008***	**Scope:** Virtual organizations (VO) are increasingly central to the science and engineering projects funded by the National Science Foundation. The Building Effective Virtual Organizations Workshop assembled a world-class lineup of speakers to help address the knowledge gap of how to establish distributed teams, how to make them successful, and what technologies exist that can help them function effectively. The goal of the workshop was to share systematic knowledge about the components, characteristics, practices, and transformative impact of effective VOs; identify topics for future research that will inform the ongoing design, development, and analysis of VOs for science and engineering research and education; and create a new cross-disciplinary VO research community to conduct research across a range of important topics. **Findings:** Workshop participants identified a number of research challenges going forward: definitions of VOs, frameworks for comparison, lifecycles, diversity, impacts of research on implementation, technology for knowledge and data sharing, collaboration within and across disciplines, human interaction, scaling, motivation and rewards, governance, and metrics and assessment. Certain development challenges also exist, including the tension between customization and shared infrastructure as well as the deployment, maintenance, and support of infrastructure. **Recommendations:** The report concludes with a set of recommendations for how to move forward: • Encourage cross-disciplinary studies involving both technologists and social scientists working with domain-centered VOs. • Combine knowledge from multiple studies to present a framework that can inform further VO research and practice. • Develop a checklist of necessary VOs features— technological, social, organizational, and so on—to ensure that new VOs start off on the right track. • Design instrumentation, metrics, and evaluation as part of a VO from the beginning rather than adding measurements systems postmortem. • Support human capital development around VOs. • Investigate whether technological and organizational factors that support effective virtualization can be standardized or provided as commoditized infrastructure. • Offer awards for supporting community services at all levels, including the development of new scientific applications, operation of technology infrastructures, and ongoing maintenance

	of these services. • Identify incentives and offer rewards for "metacontributors" to VOs—the people who build or reorganize features to make it easier for others. • Support the development of hardened common tools and protocols for sharing knowledge and data. • Create proposal funding models that support the use and reuse of VO infrastructures. • Encourage universities to support VOs with substantial, complementary investments. • Establish cross-directorate funding opportunities that could more appropriately evaluate and support projects uniting social scientists, computer scientists, and domain scientists. **Availability:** http://www.ci.uchicago.edu/events/VirtOrg2008/

<table>
<tr><td></td><td>Office of Cyberinfrastructure (OCI)</td></tr>
<tr><td>The Next Generation Research Grid: A Path Forward</td><td>Scope:

This project worked with stakeholder communities to collect ideas for the next generation of the TeraGrid. TeraGrid currently uses high-speed network connections to integrate high-performance computers, data resources and tools, and experimental facilities at eleven resource provider sites around the country. To address changes that are already occurring and are anticipated to take place in high-performance computing (HPC) and computational science over the next 5-7 years, a steering committee was convened with representatives of key stakeholder communities to facilitate a planning process to help guide the future evolution of TeraGrid. The committee was charged to provide a report to stakeholders that identified options for the definition, design, and implementation of the next generation of the NSF TeraGrid program. The committee considered the results of a series of planning workshops, hosted “town hall” meetings, solicited position papers from current TeraGrid users and other national and international stakeholders, examined relevant reports and other documents, incorporated information from the TeraGrid Evaluation Research Study, interacted individually with stakeholders, and deliberated extensively.

Findings:

The TeraGrid has been responsive to increases in the number of resource providers, the evolving technological landscape, and changes in the types of users, usage modes, and user requirements. However, the open, agile, and robust production infrastructure needed for the next generation research grid requires:
a funding model designed to support the program attributes over extended time periods
a strategic plan that includes statements of vision, mission, and values, a list of specific goals, a description of the ways in which those goals will be met, and scheduled reassessment of the plan at set intervals regularly against pre-specified metrics, and
a governance structure and a management plan that includes multiple avenues for stakeholder participation, including a formal advisory structure that reports both to the NSF and to project management.
Recommendations:

To ensure that the Next Generation Research Grid (NGRG) has the stability, direction, leadership, and community support that will be necessary to its success and to its ability to remain agile in the face of technological change, we suggest that the NSF prepare a two-step announcement of opportunity for competitive planning grants leading</td></tr>
</table>

	ultimately to the selection of an entity to manage the NGRG. The initial announcement would require proposers to describe how they would conduct a process whose end result would be: • a strategic plan, including a description of a strong and responsive governance structure and management plan (as outlined above) • a description of how standards would be used in the creation of the next generation research grid and the way in which the management structure would effect its use • plans to create an accessible and user-friendly production quality cyberinfrastructure environment • plans to provide mechanisms and procedures to enable research, development, and testing of cyberinfrastructure standards and tools, without impacting production operations of the NGRG • strategies for broadening participation to include new users, disciplines, resource providers, partners, and science gateways • processes to interoperate with Track 1 and Track 2 systems and with data storage, analysis, and visualization systems and pathways to these resources from campus level systems and other high-performance computing centers in an extensible partnership mode7 • an approach to preserve agility in the face of inevitable technological change • plans for the career development of people who will support the infrastructure and computational science • a plan to coordinate and cooperate with other national and international cyberinfrastructure providers and to provide leadership in the development of an international grid infrastructure • an allocation process matched to program attributes • an education and outreach program serving and expanding the community that will create, utilize, support, and extend the cyberinfrastructure to enable research discovery and learning for present and future generations It is vitally important that OCI and the directorates coordinate their strategic plans because in many ways the directorates are the most important customers of the next generation research grid. The NGRG should be strongly driven by the needs of current and future research communities able to make significant strides with the use of modern high-end cyberinfrastructure. Thus, in addition to the product that would result from the announcement of opportunity, mechanisms should be developed for other research programs supported by NSF directorates to coordinate with OCI and to make use of the NGRG as an integral part of their programs and to provide incentives for alignment. **Availability:** http://teragridfuture.org/