TABLE OF EXTERNAL EVALUATIONS

The Table on the following pages provides information on program assessments and evaluations other than Committee of Visitor and Advisory Committee assessments.

The Table lists other types of evaluations not used in GPRA performance assessment that were completed in FY 2006. These reports, studies, and evaluations are frequently used in setting new priorities in a field or in documenting progress in a particular area. The reader is encouraged to review the reports for additional information on findings and recommendations that are beyond the scope of this report.

Reports (other than COV reports) produced by NSF are available online at using the NSF's online document system and the publication number indicated. Reports are available here: www.nsf.gov/pubs/start.htm.

Information on obtaining reports produced by the National Research Council or National Academy of Sciences can be found online by searching www.nap.edu or from the National Academy Press, 2101 Constitution Avenue, N.W., Lockbox 285, Washington, D.C. 20055 (1.800.642.6242).

Evaluations Completed in FY 2006

	Directorate for Biological Sciences (BIO)
Mid-course Assessment of the Arabidopsis 2010 Project"	**Findings:** In 2000 the *Arabidopsis* community proposed an ambitious program to determine the function of every gene by 2010. This became the basis for the NSF 2010 Project (NSF 05-624 and prior announcements), which has funded 86 projects in the first five years. The North American *Arabidopsis* Steering Committee held a workshop in Arlington, VA on Aug. 25 and 26, 2005, to evaluate the progress made toward the specific goals of the program and to recommend directions for the next five years. Prior to the meeting, input was solicited from the community through a web-based survey to which more than 580 researchers responded. Additional information on the impact of funded projects was obtained that described the number of stocks deposited, data generated and publications resulting from 2010 projects. The workshop participants' assessment was that most of the goals for the first five years have been met or surpassed. Of particular note were the genome-wide resources including knockout lines and full-length cDNAs, which have been of remarkable utility to a large number of researchers. It was the participants' view that certain approaches toward functional analysis have had more impact than others. In particular, those that pioneered new approaches to understanding biological processes using high throughput and/or computational approaches have served as paradigms for other research efforts. In fact, it is expected that *Arabidopsis* will be the model for resource and tool development and application for all plants. **Recommendations:** For the remaining five years of the program the workshop participants recommended emphasis on the following areas: 1. Benchmarking gene function 2. Developing genome-wide tools and reagents for analyzing gene function and regulation 3. Improving genome annotation and tools for visualization, annotation and curation 4. Improving database integration and developing new modeling and computational tools 5. Exploring exemplary networks and systems 6. Analyzing non-protein coding genes 7. Leveraging natural variation to understand gene function in *Arabidopsis thaliana* 8. Localizing gene products at the cellular and subcellular level 9. Facilitating metabolomics and ionomics 10. Engaging the broader community 11. Enhancing international collaboration The workshop also looked beyond 2010 to challenges that could form the basis for an *Arabidopsis* 2020 program. This ongoing and future research program should have critical impacts on many areas of basic science, agriculture, engineering and environmental improvement as well as on all aspects of plant biology. **Availability:** **www.nsf.gov/pubs/2006/bio0601/bio0601.pdf**

The Multinational Coordinated Arabidopsis thaliana Functional Genomics Project: Annual Report 2006	**Findings**: This is the 2005/2006 annual report of the Multinational *Arabidopsis* Steering Committee (MASC) on the status of the Multinational Coordinated *Arabidopsis thaliana* Functional Genomics Project, which has completed its fifth year. The MASC is composed of representatives from each country with major *Arabidopsis* functional genomics efforts or coalition of countries with smaller programs. This report highlights the progress made over the last year by the international *Arabidopsis* functional genomics community. It also demonstrates the continued high level of cooperation that exists throughout the global community and the importance of the support by funding agencies in producing important and exciting results in plant biology. The continuing rapid progress in *Arabidopsis* functional genomics emphasizes the central role that work on this reference plant has for furthering understanding of all plants. In 2005/2006 there was a continued increase in publicly accessible data and resources including SNPs, MPSS, microarray, full length-cDNA information as well as full-length cDNA clones, ORF clones, RNAi clones and insertion mutants. Intensive international efforts have made a large number of biological resources available to the *Arabidopsis* community and the ease of access to these materials is particularly noteworthy. While there is still much to discover in the *Arabidopsis* genome and transcriptome particularly using systems approaches, new frontiers include proteomics and metabolomics. In addition, information gathering between genomes, i.e. comparative genomics and natural variation, is increasingly enabled by genome resequencing and reannotation, and the development of more sophisticated genome surveying tools and bioinformatics and data integration approaches. MASC Subcommittees focusing on Systems Biology, Metabolomics, Proteomics, and Natural Variation and Comparative Genomics recently formed to evaluate current knowledge, identify needs and bottlenecks, and establish appropriate courses of action. International cooperation by motivated researchers, a high level of coordination, and sufficient funding remain critical to the success of this ambitious project. Areas that lag behind initial plans or are currently underrepresented: 1. The improvement of database integration is critical. 2. Proteomics, metabolomics and natural variation and comparative genomics are all areas that need more emphasis. 3. Tools needed for *Arabidopsis* functional research. 4. Development of networks and systems biology is needed. 5. Temporal and spatial gene expression data are still needed under varied conditions, in specific tissues, and in different genotypes. 6. Analysis of non-protein coding genes is still lagging. **Recommendations:** ▪ Ensure the successful establishment of recently formed MASC subcommittees including Metabolomics, Natural Variation and Comparative Genomics, Phenomics, and Proteomics. ▪ Update and improve the Project's webpages at The *Arabidopsis* Information Resource (TAIR). ▪ Work toward completion of genetic resources projects including the collection of homozygous insertion mutants and RNAi clones. ▪ Develop resources for studying protein interactions and localization, including complete cloning of full length cDNAs into expression vectors. ▪ Expand data integration and interoperability efforts for optimal use of data resources. ▪ Facilitate and encourage submission of data and stocks into public repositories. ▪ Implement a Systems Biology working group. **Availability:** **www.nsf.gov/pubs/reports/2006_complete_masc_report1.pdf**

	Directorate for Education and Human Resources (EHR)
Abt Associates, Inc. and SRI International (forthcoming, 2006). ***Summary of the Formative Evaluation of the National Science Foundation's Centers for Learning and Teaching [CLT] Program: An Internal Report.***	**Findings:** ▪ All Centers are involved in graduate education, and eight of the 10 centers in Cohorts 1, 2, and 3 have multiple university partners. [There are now 5 cohorts in the CLT program.] ▪ Three Centers have adopted entirely new degree programs, two have developed new degree concentrations for students earning a STEM education doctoral degree, and the other five Centers have substantially modified existing degree programs. ▪ The number of Education faculty is rather evenly distributed among Centers, averaging 6 faculty per Center. The average number of STEM faculty involved in graduate education is two. ▪ Of the 230 doctoral students responding to the survey, 50 percent report that they were already enrolled in graduate school when they joined the CLT program. In their start-up years, Centers are more likely to draw in students who are already enrolled in participating degree programs, bringing in new students as Centers mature. [Since the initial study, aggressive recruitment efforts have resulted in a preponderance of new students.] ▪ The CLT Program has had considerable success in recruiting students with varied backgrounds. Before starting graduate school, almost two-fifths of CLT doctoral students had either taught in K-12 settings or worked in a school district Another quarter were undergraduate or graduate students without work experience. Centers have, had less success in diversifying the cadre of leaders by race or ethnicity, though several point out that they have diversified their graduate programs in other ways (such as attracting traditionally underrepresented rural or Appalachian students). [Enhanced recruitment efforts are yielding noticeable increases in participants from underrepresented groups.] ▪ CLT doctoral education is still under development. Two-thirds of the doctoral students are still taking courses, while most of the remaining third have passed qualifying exams or had dissertation proposals accepted. Doctoral students' career goals are consonant with those of the overall CLT program. That is, most students plan to conduct research/evaluation (89 percent) and/or teach at a higher education institution (86 percent) upon graduation. Centers reported that 923 teachers or other educators received CLT -sponsored professional development in academic year 2003-2004. The number of participants served by any given CLT institution varies from as few as eight at one CLT partner University to more than 150 at another. Two thirds (67 percent) of 2003-2004 professional development participants received 60 hours or less of CLT-sponsored professional development during the last academic year. ▪ Ten of the 12 Centers have made in-service teachers the primary target of their professional development efforts. Two centers are also including a few district administrators in their efforts. Some Centers, however have made other populations the targets of their professional development. One is providing professional development to two Cohorts of museum educators from across the nation. Two others are making special efforts to provide professional development to teacher professional developers.

- All Centers report that they are involved in research. Almost all report that the research is either new or substantially modified, with most of the new research being done by graduate students. Faculty typically have continued their pre-Center research efforts, albeit sometimes with new emphases that more closely reflect the Center's focus research topics mirror the programmatic emphasis of the Centers. Given that doctoral students are engaged in most of the research, it will likely be several years before research makes its way onto a national stage.

Recommendations:

DIRECTIONS FOR FUTURE RESEARCH

- *Careers of CLT Graduate Students*—Investigations to assess the net increase in, and diversity of, holders of masters' and doctoral degrees in STEM education who are expert in STEM research, curriculum development, education policy, large-scale assessment of education reform, or informal STEM education.
- *Outcomes of Center Research Efforts*—Investigations to assess increase in the volume, and improvement in quality of, STEM education research; work on interdisciplinary topics and topics that are more pertinent to current issues; wide sharing and implementation of research findings.
- *Anticipated Longer-Term Outputs*—Investigations that assess progress toward a number of anticipated long-term impacts:
    - A revitalized human resource infrastructure that meets the needs of the informal and formal STEM teaching system, including better reflection of the diversity of America's population.
    - A substantial body of research on emerging and interdisciplinary STEM education topics, and translation of research findings into practice.
    - Higher quality K-12 and informal teaching and learning in STEM fields, based on better research that leads to better policies, better practices, and better materials.
    - More, and better qualified, students applying for postsecondary education in STEM fields and to become STEM educators.
    - Closer integration of STEM academic disciplinary programs with education programs.
    - Enhancement of the reputation of the STEM educational system.

Availability: Forthcoming on contractor's web site.

ORC Macro and Guardians of Honor, LLC (forthcoming, 2006). ***A Performance Monitoring Report of the National Science Foundation's Centers for Research Excellence in Science and Technology (CREST) Program*****.**	**Findings:** ▪ Female student participants increased from 2001 to 2003. In 2001, females were 31.5 percent of CREST students. By 2003, females were 37.5 percent of CREST students. ▪ At least 69 percent of the student participants were from underrepresented groups. Black students are the largest CREST participant group for all three program years, with approximately 150 black students participating each year. ▪ Two hundred seventy-two degrees were awarded to CREST participants from 2001 through 2003. o Fifty-one percent of all degrees awarded to CREST graduates were bachelor's degrees. o Forty-three percent of all degrees awarded to CREST graduates were master's degrees. o Doctoral degrees were six percent of all degrees awarded to CREST graduates. o More than half of all degrees awarded to CREST-supported graduates were awarded in engineering. ▪ On average CREST centers were performing at least 3 activities that focused on outreach and recruitment and at least two activities that focused on retaining STEM students and helping them progress towards graduation. ▪ The number of partnerships increased from 19 in 2001, to 77 in 2003 with each Center reporting partnerships with at least three entities. ▪ Since 2001, more than 1000 manuscripts have been submitted for publication consideration by CREST faculty and students. Sixty-eight percent of all manuscript submissions have resulted in publication. ▪ The number of recognition awards received has increased from 58 awards in 2001 to 132 awards in 2003. ▪ In 2001, CREST centers received more than $22 million dollars in awards from federal and state agencies, foundations, universities as well as other sources. By 2003, CREST center awards totaled more than $52 million. ▪ Conference participation by CREST faculty and students have increased from just 22 in 2001, to more than 90 in 2003 in 25 locations across 14 countries. **Recommendations:** • To further their goal of increasing diversity, CREST Centers need to continue their recruitment of female undergraduates and graduates, increase the number of women in leadership positions, and increase the racial and ethnic diversity of their faculty. • To become self-sustaining, Centers should be encouraged to make every effort to identify and secure alternative funding sources. • To provide a clearer picture of Centers' progress in moving their research to market, more extensive data collection on product development and patent processes is needed. **Availability:** Forthcoming on contractor's web site.

Temple University—Institute for Survey Research and Caliber Associates (2006), ***Highlights of CSEMS Survey Findings 2003-2004: An Internal Report.***	**Findings:** • The majority of CSEMS institutions reported increased enrollment of students from the following target groups: financially needy (69% of institutions said so), women (59%), generally under-represented (57%), academically talented (57%), ethnic/racial minorities (55%), and first-generation college students (40%). • Students reported that without CSEMS, they would have to borrow money (79%) or work more hours for pay (71%) to finance their education. • While the majority of CSEMS students were concentrated in engineering (38%) and computer science (25%), notable patterns emerged according to gender and race/ethnicity. Female recipients, for example, comprised 35% of the CSEMS student population, but represented 44% of students enrolled in math, and 60% in engineering technology. Similarly, Black students, although 15% of the CSEMS population, made up 20% of students in engineering technology. • 72% of scholarship recipients believed that CSEMS increased their likelihood of completing a CSEMS program of study and pursuing a CSEMS-related career, and 68% reported that CSEMS increased the likelihood of their pursuing a higher degree. • 66% of PIs at 2-year institutions reported that, after implementation of CSEMS, their institutions witnessed an increase in completed CSEMS degrees; 60% reported an increase in transfers to CSEMS in 4-year schools; and 57% said that enrollments in CSEMS disciplines had increased. • 55% of PIs at 4-year institutions reported that the number of completed CSEMS undergraduate degrees had increased at their institutions after implementation of CSEMS; 51% said that enrollments in CSEMS disciplines had increased; and 47% reported an increase in students continuing beyond high attrition points (at 2-year institutions, 43% of PIs said so). 46% of PIs at 4-year IHEs reported an increase in students pursuing graduate study in a CSEMS field; 30% reported increases in completed CSEMS master's degrees, and 11% said that their institutions had seen an increase in completed CSEMS doctoral degrees. • PIs reported that CSEMS enhanced: industry experiences and internship opportunities (67%), faculty support and mentoring of students (84%), student use of tutoring and other academic services (76%), and career counseling and other job placement services for CSEMS areas (75%). • Among the services and programs used by at least half of scholarship recipients, the most helpful (according to 65% of students) was faculty support and mentoring. • Within CSEMS institutions, PIs reported that the program helped to strengthen internal relationships between participating departments (82%), between faculty and students (88%), and between faculty and administration (69%). **Recommendations:** • Conduct a longitudinal or follow-up study of CSEMS scholarship recipients in this study. • Continue to provide and enhance administrative support and technical assistance. • Conduct additional follow-up site visits to several CSEMS institutions and a follow-up principal investigator study to identify and disseminate promising practices that facilitate students' ability to complete CSEMS degrees. **Availability:** Forthcoming on the contractor's web site.

WESTAT (June 2005), *Evaluative Research Study for the NSF's Director's Award for Distinguished Teaching Scholars (DTS) Program: An Internal Report.*

Findings:

Planned Project Impact on Various Groups

- All 18 projects planned to directly impact college faculty, the median impact is at 28 faculty per project.
- Nine of the projects intended to work with K–12 or precollege teachers.
- Collaboration with faculty peers to integrate research and education was done by one-half of the awardees post-award, whereas five (28 percent) had done so prior to the award.
- Ten awardees (56 percent) were mentoring graduate students regarding the integration of research and teaching; three (17 percent) were working with graduate students to show them how to conduct educational research with respect to their teaching effectiveness
- Nearly three-quarters of the awardees offered workshops on their DTS projects in their departments and/or elsewhere in their home institutions. Eight felt that their standing as a research scholar was enhanced by the award.
- Six reported that their status as a DTS awardee had helped them have an impact on the academic culture in their departments or institutions.
- Eight recipients (44 percent) reported that the DTS award enhanced their standing as a research scholar at their home institution.
- Twenty-eight percent of DTS awardees served as leaders of professional societies in their STEM discipline's education arm, and 39 percent serve on editorial and advisory boards.
- Just under half (44 percent) have published results of their education efforts, and some reported having difficulty finding journals in their disciplines that dealt with educational issues other than those directed toward secondary teachers.
- Sixteen (89 percent) have been recognized, through venues other than the DTS Award, for their accomplishments and contributions in education, and the same number have reached out to the broader community by speaking or giving workshops at other institutions regarding the integration of research and education.

Table 7.—Number and percent of DTS awardees who report having increased visibility and prestige in their academic fields since the DTS award (N = 18)

Item	Number	Percent
Serve as leaders of professional societies in their STEM discipline's **education arm**	5	28
Are recognized for their accomplishments and contributions as **researchers**	10	56
Are recognized for their accomplishments and contributions in **education**	16	89
Serve on editorial review boards and or advisory boards or committees	7	39
Have published results of **research** efforts	9	50
Have published results of **education** efforts	8	44
Have reached out to the **broader community** in various ways about their efforts to integrate research and education—e.g., speaking or giving workshops at other institutions	16	89

	Recommendations: (Detailed suggestions and criteria for each of the following recommendations can be found in Chapter 4 of the internal report.) • Raise the profile of DTS externally beyond NSF and expand outreach efforts; • Create a DTS professional learning community; • Generate DTS/CAREER connections; • Strongly encourage DTS awardees to evaluate their activities and products; • Reconsider the size of the award; • Consider implementing a system to track awardees' future funding for activities that support the integration of research and education. **Availability:** Available upon request.

The American Institutes for Research and the Wisconsin Center for Education Research (Sept. 2005), ***Findings from the Formative Evaluation of the National Science Foundation's [Graduate Teaching Fellows in K-12 Education] GK-12 Program.***	**Findings:** • 89% of Fellows and 91% of teachers reported that the Fellows' communication skills improved either "somewhat" or "greatly/significantly" as a result of their K-12 activities. • 93% of Fellows and 90% of teachers reported that the Fellows' teaching skills improved either "somewhat" or "greatly/significantly" as a result of their K-12 activities. • Over three-quarters of teachers reported that improving the quality of their teaching (83%) or gaining content-area knowledge (79%) motivated them to a moderate or great extent to participate in the GK-12 program. • Three-quarters of surveyed teachers reported that their content knowledge in STEM subjects increased as a result of working with the Fellows by a "moderate" or "great" extent. These findings were substantiated by reports from interviewed teachers. The Fellows' work in the classrooms was reported as key to this increase in teachers' content knowledge. • 91% of teachers indicated that Fellows provided enriched learning experiences and opportunities for their students to a "moderate" or "great" extent. • 86% of teachers reported that students learned more science (or technology, engineering, or mathematics) content than they would have if the Fellow had not been there. • School staff reported that the university was more accessible, and that teachers were more connected to university resources and faculty than they were prior to GK-12. • Surveyed district staff reported greater district involvement with the university after the GK-12 Program was implemented than before implementation. **Recommendations:** (The following recommendations have been extracted from the final GK-12 evaluation technical report.) 1. Recommendations for the GK-12 program • Consider whether the support of undergraduate students is an appropriate and efficient use of program funds. [In FY 2006, undergraduate fellowships were dropped from the program. Fellowship stipends are available exclusively for STEM graduate students.] • Provide practical and actionable information and advice about effective and efficient ways to operate projects and to promote their sustainability to PIs and individuals interested in developing university-K-12 partnerships programs. • Provide more guidance to sites on how they can better evaluate the success of their projects • Provide more guidance to sites on how they can better evaluate the success of their projects [Specific guidelines about reporting and project evaluation have been developed, shared with the PIs and included in the program solicitation.]

	2. Recommendations for future evaluation work • The GK-12 program should consider developing surveys to assess the prevalence and distribution of critical partnership and/or institutionalization behaviors in the GK-12 program • A longitudinal study of Fellows could provide valuable information about the long-term effects of GK-12 participation on Fellows. • Further research could explore whether GK-12 is reaching underserved populations. **Availability:** Forthcoming on the contractor's web site.

Abt Associates, Inc. (2006), ***Final Report on the Evaluation of the Initial Impacts of the National Science Foundation's Integrative Graduate Education and Research Traineeship [IGERT] Program.*** **[NSF 06-17]**	**Findings:** IMPACTS ON STUDENTS: *The IGERT program is providing graduate students with significant interdisciplinary experiences as well as professional and personal skills for their future careers.* ▪ IGERT students consistently report greater opportunities than their non-IGERT peers to learn about other disciplines (86% compared to 55%), interact with faculty and students from other disciplines (50% compared to 22%), and work on projects involving multiple disciplines (76% compared to 42%). ▪ IGERT students receive more training than non-IGERT students in teamwork (66% compared to 50%), presentation (51% compared to 42%), and communication skills (50% compared to 22%), and are nearly twice as likely as non-IGERT peers to have received formal training in research ethics (74% compared to 39%). ▪ IGERT students report more opportunities than their non-IGERT peers to conduct off-campus internships (29% compared to 15%) and interact with people outside their home institutions (e.g., faculty from other universities, 48% compared to 34%) and outside academia (e.g., industrial scientists, 22% compared to 14%). IMPACTS ON FACULTY: *The IGERT program is promoting a fertile environment for faculty to engage in interdisciplinary teaching and research, and providing faculty with stimulating professional experiences to which they willingly devote substantial time.* ▪ While interdisciplinary activities are common among all faculty surveyed, IGERT faculty and department chairs report an additional shift towards more interdisciplinary work as a result of their participation in the IGERT program. ▪ IGERT faculty team-teach in greater frequencies than non-IGERT faculty with colleagues outside their departments (42% compared to 28%) and mentor graduate students from other disciplines (67% compared to 47%). ▪ More IGERT faculty than non-IGERT faculty publish and present their research in journals (63% compared to 48%) and conferences (60% compared to 44%) outside their home disciplines, and are more likely to work on research projects (90% compared to 78%) and co-author proposals (86% compared to 64%) with colleagues from other disciplines. ▪ About half of IGERT faculty report learning new research techniques, exploring research that would not otherwise be funded, or being in a better position to win new grants as a result of IGERT. IMPACTS ON INSTITUTIONS: *The IGERT program is helping to advance interdisciplinary graduate education in host institutions as well as catalyzing changes in graduate education beyond them.* ▪ Project PIs report that IGERT projects have stimulated policy changes for interdisciplinary coursework (68%) and teaching (34%), the revision of degree requirements (49%), and the creation of new degrees and certificates

(23% respectively), as well as increases in university support for interdisciplinary education in general.
- Faculty members and department chairs perceive stronger departmental and institutional support for interdisciplinary research at IGERT institutions than non-IGERT institutions.
- Many PIs and administrators report that other departments or programs at their home institutions have already adopted IGERT program elements.

IMPACTS ON RECRUITMENT: *The IGERT program has the potential to increase the number of U.S. citizens currently enrolled in STEM doctoral programs.*
- IGERT faculty report an increased ability to recruit more and better academically qualified individuals to their programs.
- IGERT PIs and faculty members report recruiting high quality students, including those students for whom the availability of an IGERT program was a factor in choosing to attend graduate school.
- The IGERT program has recruited women and students from underrepresented minority groups in science and engineering programs at rates equal to national averages, and will seek further increases in these rates of recruitment.

Recommendations:

DIRECTIONS FOR FUTURE RESEARCH

The IGERT program represents a substantial investment in domestic graduate education, and new projects continue to be funded each year. As such NSF, the program community, and graduate education at large can benefit from continued evaluation and assessment of the IGERT program. As individuals begin graduating in larger numbers from IGERT projects, and grant funding draws to a close for many projects, there are several topics of investigation that might be of interest to the NSF and the graduate education community.

- *Assessment of Diversity Enhancement*—To enhance access to STEM doctoral education for populations traditionally underrepresented in science (such as minority groups and women), many IGERT projects have begun establishing recruitment relationships with programs or institutions that target individuals typically underrepresented in STEM fields. Future research could examine successful recruitment strategies, and the IGERT program's ability over time to recruit higher proportions of individuals from these groups.
- *Assessment of IGERT Graduate Career Outcomes*—A longitudinal study of the career outcomes of IGERT graduates, to learn about their chosen career pathways, professional productivity and accomplishments, would be an important measure of the long-term impact of the IGERT program.

- *Assessment of IGERT Institutional Impacts*—As the IGERT program evolves there will be opportunities to learn about continued institutional culture change and the lasting institutionalization of program elements. There are several possible methods of studying such impacts. First, to learn more about the impact of IGERT projects on their host institutions, individuals external to the IGERT project but within the same institution could provide a useful perspective on IGERT and its impact. Second, long-term institutional impacts and project sustainability can be examined after a project's funding has ended. Third, future studies could collect data from other points in time, enabling a longitudinal analysis of institutional support and enabling conclusions to be drawn about the ways in which IGERT projects effect lasting change in their universities.
- *Assessment of the IGERT Model of Interdisciplinary Graduate Education*—Future evaluation work should examine the IGERT model of graduate education itself. In what ways are IGERT activities "interdisciplinary" or "integrated"? What do these terms mean on IGERT campuses? How can the IGERT program help develop a broader understanding of what it means to engage in integrated and interdisciplinary graduate education? How does the IGERT program compare to other interdisciplinary graduate education programs as an effective means of reaching the goals of the IGERT program?

Availability: www.nsf.gov/pubs/2006/nsf0617/nsf0617.pdf

Westat, Inc. (June 2006), ***Analysis of a Sample of Projects Funded Under the [Informal Science Education] ISE Program.***	**Findings:** MUSEUM PROJECTS—Museum exhibit projects used formal interviews (i.e., exit interviews), observation, external reviewers, tracking studies, surveys (teacher, student, and visitor), and focus groups to measure effectiveness. Oftentimes, tracking studies were used during the formative stages of the exhibit to inform placement and content. ▪ Numbers of visitors ranged from 25,000 to over a million. *1,2,3 Ready, Set, Go! Math for Young Children and Families* used a parent survey to understand how the exhibit impacted their children. ▪ The *Alien Stingers Exhibit* reported summative evaluation results from exit interviews with 423 randomly selected visitor groups. Findings show that the exhibit "changed perceptions of jellies, addressed visitors' concerns about stinging, increased visitors' ability to articulate any value that jellies and coral have for ocean ecosystems, and created positive associations for visitors concerning scientific inquiry generally." TELEVISION, RADIO, AND WEBCAST SHOW PROJECTS—Television, radio, and Webcast projects utilized administrative records (website hits), external records (independent ratings, number of viewers), focus groups, telephone interviews, pre/post-testing of viewers, observation, and chat logs to ascertain the impact of their programs. Oftentimes, projects were considered successful if a show garnered a large segment of the market share, viewers enjoyed the show, and viewers acquired new knowledge from the show. ▪ *Science News for Local TV and Spanish Stations* found that viewership varied depending on the topic. o health related topics averaged 3.5 million viewers o technology related topics averaged 2.1 million viewers, o physics related topics averaged .5 million viewers, o all stories combined averaged 1.2 million viewers. ▪ *DragonflyTV* found that 95 percent of the children understood the premise of the program, and 80 percent wanted to try their own science projects. ▪ *Zoom* offered findings involving children's acquisition of knowledge, the involvement of parents in the children's science activities, and level of engagement in science activities after viewing the show. Overall, the project found that children who watched the show were more likely to engage in their own science activities. SCIENCE / MATH PROGRAMS FOR YOUTH—Science and/or math programs for youth projects used web, telephone, and in-person surveys of parents, teachers, and participants to assess program success. Administrative records were also used to ascertain if programs were meeting their target underserved audiences. Measures of success were often reported in terms of participation rates and satisfaction of parents/students/teachers. ▪ The number of participants in science/math programs for youths ranged from 107 to more than 6 million ▪ *Wonderwise 4-H* project used a web survey to assess the program's impact on the participants. Many students pointed out that "the activities and videos affected the youth's perceptions of a career in science or that youth indicated an interested in or intention of becoming a scientist." A significant portion of the adult leaders stated that "by seeing minority women who have families, and who are also scientists, youth recognized that they, too, could become scientists one day as well."

RESEARCH / PROGRAMS FOR PROFESSIONALS—Research and/or educational programs for professionals often used formal interviews, external evaluations, mail surveys, and informal conversations to obtain feedback about the success of their research or program. The surveys usually assessed the usefulness of information presented and participant satisfaction. For projects designed to explore research questions, sometimes pre- and post-testing were used as a method to test hypotheses.

- Conference and Proceedings: *Best Practices in Science Exhibition Development*, held at the Exploratorium in San Francisco, California, provided professional development to over 50 exhibit developers and generated a publication for the entire field.
- *Mother Goose Cares about Math and Science: An Integrated Course of Science and Mathematics for Child Care Providers* provided training for over 600 child care professionals.

FILM PROJECTS—Film projects used administrative records (number of attendees), pre/post-testing, external evaluation, surveys (telephone and in-person), and critical reviews to assess the success of their productions.

- *Coral Reef Adventure* reported an estimated 5.08 million viewers. The *Coral Reef Adventure* found that on a 10-point knowledge test, average scores increased from five to eight correct answers after people had viewed the film.
- The *Jane Goodall Project* found that students who watched the film did better than a control group on a test designed to measure student learning about wild chimpanzee behavior.

Recommendations

The ISE program staff will need to assess the impact of new guidelines in the solicitation, which require projects to demonstrate impact on the ISE field, innovation, and collaboration. Specifically, future evaluation activities should assess the degree to which:

- projects have become "audience-driven" vs. "content-driven" and are developing clear and appropriate mechanisms/approaches for evaluating progress and strategic impacts;
- project approaches build upon previous research and advance "the-state-of-the-art" in informal science education;
- new research methods and measures (developed by selected projects) serve to inform other future project evaluations.

Availability: Forthcoming on contractor's web site**.**

The Urban Institute (Nov. 2005), ***Final Report on the Evaluation of the National Science Foundation Louis Stokes Alliances for Minority Participation Program*****.**	**Findings:** INSTITUTIONAL OUTCOMES—Project staff members who were interviewed at participating institutions of higher education believe that involvement in the program enables institutions to retain and graduate more STEM students by substantially expanding these institutions' capacity to develop and support STEM student talent. Staff members also believe that LSAMP had an impact on participating institutions by changing the institutional culture, policies, and practices to encourage the recruitment, retention, and graduation of underrepresented minorities in STEM majors. NATIONAL COMPARISON—LSAMP student outcomes and those of STEM graduates nationally and LSAMP graduates' progress in the STEM pipeline was compared with that of nationally representative samples of underrepresented minorities and white and Asian students (using longitudinal data from NSF's National Survey of Recent College Graduates). Analyses revealed that LSAMP participants pursued post-bachelor's coursework, enrolled in graduate programs, and completed advanced degrees at greater rates than did national comparison groups. The difference in graduate school enrollment and completion is largely due to the significantly higher percentage of LSAMP students pursuing and completing degrees in STEM fields. In terms of the final phase in the STEM pipeline, LSAMP participants were observed joining the STEM workforce in proportions similar to those of national samples. STUDENT OUTCOMES ▪ 80% of LSAMP students took further coursework after completing their bachelor's degree, compared with about 60 % of comparison URM and white and Asian students. ▪ 66% of LSAMP participants pursued graduate degrees (compared to 45% among the comparison groups. ▪ LSAMP participants are about 50 % more likely to pursue an MA or a PhD than are those in either comparison group. ▪ 38% of all LSAMP students pursued graduate degrees in STEM, compared with 20 to 22 % among the comparison groups. ▪ About 45% of LSAMP students completed graduate degrees, while this was true of about 20 % of national URM and white and Asian bachelor's degree holders. ▪ 25% of LSAMP participants completed a graduate degree in STEM compared to only 9% in either comparison group. ▪ Restricting this comparison to those respondents who completed a degree shows that LSAMP students are still more likely to have completed a graduate degree in STEM (57%) than are comparison URMs (43%) or whites and Asians (51%). ▪ LSAMP students in general were slightly more likely to complete a degree in STEM (25% of all LSAMP participants) than in a non-STEM field (19% of all LSAMP). ▪ Almost 70% of completed master's degrees were in a STEM field, as were nearly 90% of completed PhDs. As expected, given the NSF definition of STEM, the exception to this trend was professional degrees; over 80% of completed professional degrees were awarded in a non-STEM field.

Recommendations:

1. *Increase data collection efforts*. LSAMP Alliances should collect the following additional data on Level I participants :

- Undergraduate retention and attrition information about participants so that the program's success in retaining participants may be assessed.
- Tracking information that may be used to follow up on participants in order to ascertain whether or not they remain in the STEM career track by enrolling in a STEM graduate program and/or entering the S&E workforce.

2. *Strengthen the focus on community college students*. In light of the program's success in retaining in the STEM pipeline underrepresented minority students who begin their college education in community colleges, LSAMP should place added emphasis on strengthening and expanding the community college component of the program. Community colleges enroll more than half of all underrepresented minority students in postsecondary education and thus provide a promising source of potential STEM students.
3. *Expand the program to offer graduate school tuition and support to LSAMP graduates.* LSAMP graduates who did not continue taking courses after completing a bachelor's degree cited financially related factors as reasons for not doing so. The need to work and other financial burdens figured prominently among the most important barriers to LSAMP students' enrollment in graduate education, and these factors were cited by a significantly higher percentage of LSAMP graduates than their peers in both comparison groups. Given LSAMP's success in preparing participants to enter and complete graduate degrees, extending the program's offerings to include financial incentives to encourage these students to enter graduate STEM programs seems a worthwhile investment.
4. *Emphasize successful factors in selecting sites to receive LSAMP awards*. In awarding LSAMP grants, the program should continue to consider three criteria of utmost importance in identifying potentially successful applicants:
(1) evidence of institutional and faculty support; (2) history of, or plans for, a strong collaborative relationship among partners; and (3) well-defined plan and the capacity to provide the integrative services that comprise the LSAMP model.
5. *Replicate and expand the LSAMP program*. Given LSAMP's proven success, it is important that efforts to replicate and disseminate the model be increased. The LSAMP model, unlike most intervention efforts for increasing URM participation in STEM, lays the foundation for systemic institutional change. It does so, in large part, by synergistic efforts of institutional partners who can collaborate and share resources, information, and experiences.

Availability: www.urban.org/UploadedPDF/411301_LSAMP_report_appen.pdf

U.S. Office of Personnel Management [FY2006], *The Federal Cyber Service: Scholarship for Service [SFS] Baseline Evaluation Report.*	**Findings:** IMPLEMENTATION • The SFS program first enrolled students in 2001 and to date has accepted a total of 730 students in 30 universities; 443 students have graduated. Student placement has improved from 81% in 2003 to 93% in 2005. The cumulative placement rate is 88%. NSF FUNDING TO UNIVERSITIES FOR SCHOLARSHIPS • To date, $77,768,791 in scholarship funds has been distributed to universities designated by the National Security Agency (NSA) and the Department of Homeland Security (DHS) as Centers of Academic Excellence in Information Assurance Education. Most PIs are satisfied with the adequacy of funding for scholarships. However, some problems related to compensation for time devoted to SFS, as well as some inequities in the geographic distribution of funds relative to the cost-of-living, remain. • Based on data provided by the PIs, 75% of SFS students have GPAs above 3.5, indicating that the program attracts high-quality students. • Survey results of current students indicate that 57% had a formal or informal mentor in their university; 44% said they had a mentor during their internships. Two-thirds of SFS graduates agreed that mentoring had contributed to their career success. • Retention of qualified Cyber Service candidates in Federal service remains a challenge. Survey results show that turnover intention was relatively high among graduates, with 43% indicating that they were considering leaving their jobs. This is higher than the average of 31% for Federal employees with tenure of three years or less who responded to the 2004 Government-wide Federal Human Capital Survey. • Survey comments indicate considerable unhappiness with the lengthy Federal hiring and security clearance process. OVERALL PARTICIPANT SATISFACTION • Overall satisfaction with the program was high. About 80% of students and graduates expressed satisfaction, compared with 78% of PIs. IT supervisors of SFS interns and graduates were most satisfied (89%). **Recommendations** DIRECTIONS FOR FUTURE RESEARCH Future evaluation of the SFS program should include investigations into the following areas: • Retention of SFS participants in targeted government positions; • Diversity of SFS graduates relative to the Federal IT workforce; • Effectiveness of ongoing SFS program marketing efforts; • How scholarships are funded in CAEIAEs; • Procedures for placement of students in internships; • Issues related to security clearance, internships and Federal job placement. **Availability:** www.sfs.opm.gov/

Horizon Research, Inc. (November, 2005), ***Lessons from a Decade of Mathematics and Science Reform: A Capstone Report for the Local Systemic Change through Teacher Enhancement Initiative [Teacher Enhancement] TE Program***	The decade-long, Local Systemic Change (LSC) Initiative was a component of NSF's Teacher Enhancement program. All LSC projects participated in a standardized CORE program evaluation. Data collection included observations of 2,400 professional development (PD) sessions and 1,620 mathematics and science lessons, as well as 75,000 teacher questionnaires; 17,380 principal questionnaires; and 1,782 teacher interviews. LSC-developed classroom observation protocols are used nationally, beyond the LSC, to evaluate instruction and help the education community develop a vision of effective mathematics and science instruction. A number of project-based research studies addressed issues related to district-wide professional development and student achievement. **Impact:** • The 88 LSC projects (representing a nearly $250 million investment) involved approximately 70,000 teachers in roughly 4,000 schools, in 467 districts across the United States. An estimated 2,142,000 students received instruction from LSC-treated teachers each year. • The program portfolio studies strategies in a variety of contexts: **(a) content area**-K-8 science [38], secondary science [6], K-8 mathematics [18], secondary mathematics [14], elementary mathematics/ science [6], K-12 science [1], and K-12 mathematics [5]; **(b) student demographics—**white [48%], African-American [23%], Hispanic [21%], Asian [6%], American Indian/Alaskan Native [1%], other [1%]; and **(c) community-type-**urban [49%], suburban [25%], rural [13%], towns/small cities [13%]. **Findings:** • PD that addresses content and pedagogy in the context of district-selected, high-quality materials results in higher quality classroom instruction. • IMPACT ON PROFESSIONAL DEVELOPMENT: The quality of LSC-PD increased significantly over time in creating a PD culture conducive to teacher learning; improving preparation of PD providers; and preparing teachers' use of high-quality materials and related pedagogy in classrooms. • IMPACT ON TEACHERS AND TEACHING: Teachers' attitudes toward reform and perceptions of their content and pedagogical preparedness to teach science and mathematics improved with increased participation with LSC PD. LSC PD resulted in: **(a)** improved lesson quality; **(b)** increased time spent on science/mathematics instruction in elementary grades; **(c)** enhanced quality of content; **(d)** more frequent use of investigative practices, questioning, and sense making; and **(e)** classroom cultures better promoting intellectual rigor and student engagement. Improvements in classroom instruction was positively correlated with hours of LSC-supported PD. • IMPACT ON WIDESPREAD USE OF HIGH-QUALITY MATERIALS: PD around district-selected, high-quality materials increases their classroom use by participating teachers and reinforces curriculum adoption decisions. LSC PD positively impacted preparedness to teach and actual classroom practice in science and mathematics most markedly through 80 hours of participation. Evident regardless of teachers' content preparation, this helped narrow initial differences between teachers with strong and weak content preparation in terms of comfort level with science/mathematics teaching.

- IMPACT ON INSTITUTIONALIZATION OF PD SYSTEMS AS A CONTEXT FOR IMPROVEMENT: Evidence of sustainability manifested across projects by **(a)** cadres of master teachers with strong commitment to district-based PD; **(b)** partnerships of K-12 systems and university faculty leading to new courses for veteran and future teachers; **(c)** district-based materials management systems to distribute/replenish curricula/instruction kits; **(d)** alignment of financial resources, policies, and vision; and **(e)** alignment of teacher evaluation with district vision for mathematics and science teaching and learning.

Recommendations:

- Principles for effective, system-wide PD should include: **(a)** PD providers with in-depth content understanding and expertise in K-12 mathematics and science education; **(b)** supportive and collegial PD cultures facilitating teacher learning; **(c)** providing experiences that deepen teachers' knowledge of the mathematics/science content in curriculum and related pedagogy; **(d)** providing teachers opportunities to explore and become conversant with high-quality instructional materials and the appropriate pedagogy for using these materials in their classrooms; and **(e)** providing teachers support in content, pedagogy, and materials over the course of implementation.
- LSC's PD goal of 130 hours per teacher was reached by only 18 percent of teachers, although LSCs provided more PD than would have been reached with comparable funding. Programs need to attend to **(a)** teacher turnover (mobility across schools/content area, retirement, resignation, staff downsizing, reduction in classroom size); **(b)** securing state-/district-supported PD days; **(c)** levels of adoption of selected instructional materials and high stakes assessments; and **(d)** sheltering teacher workforce from changes in externally-set PD priorities over time.
- District-wide, PD-based reform requires strategies for **(a)** Increasing preparation of PD providers in areas posing difficulties for teachers (e.g., content, questioning, closure); **(b)** increasing time for teachers' content development; **(c)** increasing on-going individual and small group opportunities through increased school support and formal structure; **(d)** actively engaging principals and school administrators to secure resources and sustain efforts; and **(e)** managing turnover, entry of new teachers, and creating incentives beyond "pioneer" teachers.
- In addition to program evaluation required of participating projects from the inception of an initiative, develop a robust research agenda to increase the knowledge-based around critical program goals and design elements. Qualitative and quantitative research findings should explore multiple aspects of student impact (e.g., achievement, increased course-taking, advanced course-taking), teacher impact (e.g., content knowledge, increased class time devoted to science and mathematics, use of selected curricula), and sustainability within systems after funding ceases.

Availability: www.horizon-research.com/reports/2006/capstone.php

	Directorate for Engineering (ENG)
International Assessment of Research and Development in Systems Biology (2005)	**Findings** The interest generated by the need to integrate molecular data into a systems approach stimulated events over the last five to seven years in the U.S. and more recently elsewhere where large investments in systems biology began to be made by national entities and research institutions. The lead position of the U.S. is reflected in the larger number of active groups, greater number of educational programs underway, and the more diverse and growing funding base. There is evidence of rapid development outside of the U.S. Overall, the picture is of an active field in the early stages of explosive growth. Models for data production and data storage in systems biology are highly variable, ranging from large centers with massive accumulations of high-throughput data, to small databases. Whichever model is used, the absence of data standards that permit groups other than the producer to use, analyze, and evaluate the results is clearly a significant barrier to progress. This is an international issue and must be solved by broad collaborative interactions. The future of systems biology will depend on three critical elements: education of a new generation of scientists who have both biological and mathematical training; the availability of funding that operates outside of disciplinary boundaries; and the availability of supportive infrastructure that can accommodate the needs of an intrinsically interdisciplinary research area. **Recommendations:** None **Availability:** www.wtec.org/reports.htm

International Assessment of Research and Development in Micromanufacturing	**Findings** The U.S. gets high marks for nanotechnology R&D, but emphasis in the U.S. on micromanufacturing R&D is lagging far behind the rest of the world. This will undoubtedly have serious long-term implications, since it is well-recognized that micromanufacturing will be a critical enabling technology in bridging the gap between nanoscience and technology developments and their realization in useful products and processes. The U.S. gets particularly low marks for government funding of micromanufacturing R&D and the development and nurturing of industry, government, and university interactions and collaborations. On this latter point, Europe appears to be very strong, particularly as these partnerships work to refine and fine-tune developments for industry adaptation and commercialization. **Recommendations:** None **Availability:** www.wtec.org/micromfg/workshop/proceedings/Entire-Proceedings.pdf

Building a Better Delivery System: A New Engineering/Health Care Partnership	**Findings:** A partnership between health care professionals and engineers is critical to transform the U.S. health care sector. This can be accomplished via a systems engineering analysis approach to health care delivery. Statistical process controls, queuing theory, quality function deployment, failure-mode effects analysis, modeling and simulation and human factors engineering have been adapted to applications in health care delivery and used to improve the performance of discrete care processes, units and departments. Very few health care professionals or administrators are equipped to think analytically about health care delivery as a system or to appreciate the relevance of systems-engineering tools, however. The widespread use of systems-engineering tools will require determined efforts on the part of health care providers, the engineering community, state and federal governments, private insurers, large employers and other stakeholders. **Recommendations:** • Private insurers, large employers and public players including the Federal Center for Medicare and Medicaid Services and state Medicaid programs should provide more incentives for healthcare providers to use system tools to improve care quality and efficiency of care delivery. • Outreach and dissemination efforts that have used or promoted systems-engineering tools in healthcare delivery should be expanded, integrated into existing regulatory and accreditation frameworks and reviewed to determine whether, and if how, better coordination might make their collective impact stronger. • The use and diffusion of systems engineering tools in health care delivery should be promoted by a National Institutes of Health Library of Medicine website that provides patients and clinicians with information about, and access to systems engineering tools for healthcare. • Federal research and mission agencies should increase support for research to advance the application and utility of systems engineering in health care delivery. In addition, federal agencies and private institutions should support the development of systems engineering curriculum tools to train individual patients and care providers. • Research and development in information and communication technologies for health care delivery is necessary and should be supported in such areas as voice-recognition systems and human-information/communication technology system interfaces. • Public and private support for research on the development of very small, low-powered biocompatibility devices which are essential for improving health care delivery. Engineering research should focus on defining architecture capable of incorporating date from these microsystems into the wider health care network and into developing interface standards and protocols to implement a larger network. • The federal government, in partnership with the private sector, academic institutions and state governments should establish multidisciplinary centers of higher learning to address the quality and productivity challenges facing the nation's health care delivery system. A lead agency should be identified to ensure adequate, stable funding • Health care providers and educators should ensure that future health care professionals have a basic understanding of how systems engineering and information/communication tools work and their potential benefits. In turn, health care issues should be introduced into the engineering curriculum at all levels. Business curriculums should use health care related examples to train future health care administrators in relevant issues. Fellowship programs should be created by federal mission agencies and private sector foundations in health systems engineering and management. **Availability:** www.nationalacademies.org/onpi/030909643X.pdf

Instrumentation and Metrology for Nanotechnology	**Findings:** Instrumentation and metrology are integral to the emerging nanotechnology enterprise, and crosscut all areas of the National Nanotechnology Initiative. Advances in fundamental nanoscience, design of new nanomaterials, and ultimately manufacturing of new nanotechnology-based products all depend on the capability to accurately and reproducibly measure properties and performance characteristics at the nanoscale. **Recommendations:** • Develop a national technology roadmap for nanotechnology for instrumentation and metrology • Develop strong educational programs and leverage federal laboratories that address the development of measurement infrastructure and advanced measurement instrumentation • Coordinate funding of educational programs with agencies to provide effective support for program areas of joint interest • Leverage national laboratories' user facilities to foster the development of new measurement techniques and development of a national user facility for nanotechnology • Foster the development of consortia co-funded by government and industry tasked to bridge the gap for the development of sector-specific instrumentation of nanometrology for nanomanufacturing • Invest in integrated computational methods to develop predictive and assessment tools for nanometrology and nanomanufacturing **Availability:** www.nano.gov/NNI_Instrumentation_Metrology_rpt.pdf

2005 Survey of Nanotechnology in U.S. Manufacturing Industry – Trends and Strategies	**Findings:** Many innovations in new nanomaterials and product forms are in commercial development across the board; however there is a cautious move towards advanced generation nano-products. The near-term trend is primarily in "designer" (application-specific) passive nanomaterials with tighter size distributions, consistency and functionality as a result of improved processes, uniformity and yields. Nanotechnology has historically followed and will continue to follow an evolutionary path, with many incremental steps, demonstrating new applications (near term) in the next 3-5 years in passive applications. In combination, these small steps will result in broad and significant impact (near term) on system miniaturization, reliability, durability, efficiency, safety, comfort, productivity, and performance. This evolutionary impact can be accelerated by public-private, strategically focused research and development (R&D) and entrepreneurial initiatives. **Recommendations:** ▪ Collaborative R&D advances to reduce and combine process steps and develop new equipment to improve product yields. ▪ Government incentives for private R&D Investments and investment in pre-competitive R&D. ▪ Promote and facilitate supplier-end user partnerships to respond to intellectual property concerns and long market entry time. ▪ Streamline process to partner with academia & National Labs. ▪ Streamline permit/product approvals at government agencies and allow for broader dissemination of findings to address regulatory or safety concerns. ▪ Retrain Tech Workforce in Basic Science/Testing/QC and attract students to science & engineering careers to increase workforce. **Availability:** **www.ncms.org/publications/PDF/05NCMSNanotechnologySurveyAbstract.pdf**

Facing Hazards and Disasters: Understanding Human Dimensions, Committee on Disaster Research in the Social Sciences, Future Challenges and Opportunities, Division on Earth and Life Sciences, National Research Council	**Recommendations:** • Comparative research should be conducted to refine and measure core components of social vulnerability and resilience to hazards of all types, to address the special requirements of confronting disasters caused by terrorist acts, and to advancing knowledge about mitigation, preparedness, response, and recovery related to disasters having catastrophic physical and social impacts. • Strategic planning and institution building are needed to address issues related to the management and sharing of data on hazards and disasters (hazards and disaster informatics), sustain the momentum of interdisciplinary research, advance the utilization of social science findings, and sustain the hazards and disaster research workforce. • NSF and DHS should jointly support the comparative research, strategic planning, and institution building called for in Summary Recommendations 1-2. **Availability:** **newton.nap.edu/catalog/11671.html#orgs**

Simulation-Based Engineering Science: Revolutionizing Engineering Science through Simulation (2006)	**Findings:** SBES is a discipline indispensable to the nation's continued leadership in science and engineering. It is central to advances in biomedicine, nanomanufacturing, homeland security, microelectronics, energy and environmental sciences, advanced materials, and product development. There is ample evidence that developments in these new disciplines could significantly impact virtually every aspect of human experience. Formidable challenges stand in the way of progress in SBES research. These challenges involve resolving open problems associated with multiscale and multi-physics modeling, real-time integration of simulation methods with measurement systems, model validation and verification, handling large data, and visualization. Significantly, one of those challenges is education of the next generation of engineers and scientists in the theory and practices of SBES. There is strong evidence that our nation's leadership in computational engineering and science, particularly in areas key to Simulation-Based Engineering Science, is rapidly eroding. Because competing nations worldwide have increased their investments in research, the U.S. has seen a steady reduction in its proportion of scientific advances relative to that of Europe and Asia. Any reversal of those trends will require changes in our educational system as well as changes in how basic research is funded in the U.S. **Availability:** **www.nsf.gov/publications/pub_summ.jsp?ods_key=sbes0506**

Report on NSF Tribal Colleges Workshop (2006)	**Recommendations:** *National Science Foundation:* • Incorporate a funding structure similar to that used by the Tribal Colleges and University (TCUP) Program that accounts for the unique needs and differences in preparation of the individual TCUs. • Improve the physical infrastructure for supporting NSF pre-engineering and engineering degree programs including teaching and research labs and some technology infrastructure to support common distance based efforts. • Establish "Centers of Excellence" or "Collaborative Centers" that capitalize on the strengths of individual TCUs with the intention of disseminating and sharing expertise and best practices, related to STEM student retention, developmental education, and engineering programs. • Encourage collaboration between TCUs and NSF to better define the broader impact statement in solicitations that encourage mutually beneficial partnerships between TCUs and mainstream institutions. *Tribal Colleges & Universities:* • Develop a strategy for recruiting and retaining faculty with experience in engineering. • With NSF's support, organize SWAT or technical assistance teams to coordinate activities such as: curriculum alignment between TCUs and mainstream institutions; common distance based course development and delivery; navigating the ABET accreditation process; and to find common solutions related to engineering programs at TCUs. • Support faculty professional development, and provide release time for faculty research in order to improve faculty retention. • Develop mutually beneficial matriculation programs to transfer students completing pre-engineering programs at TCUs to mainstreams institutions that offer four year engineering degrees • Build bridges and understanding of engineering between tribal governing bodies and TCUs. • Develop mutually beneficial programs with K-12 schools with the intention of improving the math and science background of students entering TCUs. • Develop common standards for coursework among regional TCUs and four-year engineering degree granting institutions by aligning STEM course descriptions to aid in articulation and transfers and to encourage the sharing of TCU faculty and resources for common distance based curriculum. • Offer culturally appropriate curriculum that capitalizes on the incorporation of indigenous knowledge in engineering programs. • Form an *ad hoc* committee related to pre-engineering and engineering activities and an accompanying website that will be used as a portal for disseminating ideas, opportunities and facilitating collaboration. • Refine and disseminate successful models of adult recruitment, remediation, and retention in math, science, and engineering courses and degree programs. • Stimulate the interest of K-12 students in the areas of engineering by developing culturally relevant applications of engineering that are offered using informal methodologies of instruction as well as locations. **Availability:** **www.nsf.gov/attachments/106803/public/TCU_Report_Final.doc**

	Directorate for Mathematical and Physical Sciences (MPS)
Controlling the Quantum World ***Committee on AMO2010, National Research Council***	**Scope:** Atomic, molecular, and optical (AMO) science demonstrates powerfully the ties of fundamental physics to society. Its very name reflects three of 20th century physics' greatest advances: the establishment of the atom as a building block of matter; the development of quantum mechanics, which made it possible to understand the inner workings of atoms and molecules; and the invention of the laser. The purpose of this report is to identify the most promising future opportunities in AMO science based on what is known at this time. Building on these findings, the report describes the most fertile avenues for the next decade's research in this field. **Findings** This report concludes that research in AMO science and technology is thriving. It identifies, from among the many important and relevant issues in AMO science, six broad grand challenges that succinctly describe key scientific opportunities available to AMO science: • Revolutionary new methods to measure the nature of space and time with extremely high precision have emerged within the last decade from a convergence of technologies in the control of the coherence of ultrafast lasers and ultracold atoms. This new capability creates unprecedented new research opportunities. • Ultracold AMO physics was the most spectacularly successful new AMO research area of the past decade and led to the development of coherent quantum gases. This new field is poised to make major contributions to resolving important fundamental problems in condensed matter science and in plasma physics, bringing with it new interdisciplinary opportunities. • High-intensity and short-wavelength sources such as new x-ray free-electron lasers promise significant advances in AMO science, condensed matter physics and materials research, chemistry, medicine, and defense-related science. • Ultrafast quantum control will unveil the internal motion of atoms within molecules, and of electrons within atoms, to a degree thought impossible only a decade ago. This is sparking a revolution in the imaging and coherent control of quantum processes and will be among the most fruitful new areas of AMO science in the next 10 years. • Quantum engineering on the nanoscale of tens to hundreds of atomic diameters has led to new opportunities for atom-by-atom control of quantum structures using the techniques of AMO science. There are compelling opportunities in both molecular science and photon science that are expected to have far-reaching societal applications. • Quantum information is a rapidly growing research area in AMO science and one that faces special challenges owing to its potential application in data security and encryption. Multiple approaches to quantum computing and communication are likely to be fruitful in the coming decade, and open international exchange of people and information is critical in order to realize the maximum benefit. **Recommendations:** Recommendation: In view of the critical importance of the physical sciences to national economic strength, health care, defense, and domestic security, the federal government should embark on a substantially increased investment program to improve education in the physical sciences and mathematics at all levels and to strengthen significantly the research effort.

Controlling the Quantum World ***Committee on AMO2010, National Research Council***	Recommendation. AMO science will continue to make exceptional contributions to many areas of science and technology. The federal government should therefore support programs in AMO science across disciplinary boundaries and through a multiplicity of agencies. Recommendation. Given the critical role of theoretical research in AMO science, the funding agencies should reexamine their portfolios in this area to ensure that the effort is at proper strength in workforce and funding levels. Recommendation. The federal government should implement incentives to encourage more American students, especially women and minorities, to study the physical sciences and take up careers in the field. It should continue to attract foreign students to study physical sciences and strongly encourage them to continue their scientific careers in the United States. **Availability:** www.nap.edu/catalog/11705.html
Revealing the Hidden Nature of Space and Time: Charting the Course for Elementary Particle Physics ***Committee on Elementary Particle Physics in the 21st Century, National Research Council***	**Scope:** A national discussion about the future of U.S. global leadership in science, technology, and innovation has been unfolding over the past few years. In October 2005, echoing widespread concerns, the National Academies report *Rising Above the Gathering Storm* outlined a program designed to enhance the U.S. science and technology enterprise so that the nation can sustain its cultural vitality, continue to provide leadership, and successfully compete, prosper, and be secure in an increasingly globalized world. In particular, the report identified basic research in the physical sciences as a key underpinning of the nation's strategic strengths. Against this broader backdrop, the work of the Committee on Elementary Particle Physics in the 21st Century took on a special significance. By recognizing the need for U.S. leadership in particle physics, and by articulating an approach to ensuring that leadership, this report offers a compelling opportunity for action in the national discussion of the U.S. role in science and technology. **Findings** The committee arrived at several strong conclusions regarding both particle physics and the U.S. role in this global scientific and technological enterprise: Particle physics plays an essential role in the broader enterprise of the physical sciences. It inspires U.S. students, attracts talent from around the world, and drives critical intellectual and technological advances in other fields. Although setting priorities is essential, it also is critical to maintain a diverse portfolio of activities in particle physics, from theory to accelerator R&D to the construction and support of new experimental facilities. The committee believes that accelerators will remain an essential component of the program, since some critical scientific questions cannot be explored in any other manner.

Revealing the Hidden Nature of Space and Time: Charting the Course for Elementary Particle Physics ***Committee on Elementary Particle Physics in the 21st Century, National Research Council***	The field of elementary particle physics is entering an era of unprecedented potential. New experimental facilities, including accelerators, space based experiments, underground laboratories, and critical precision measurements of various kinds, offer a variety of ways to explore the hidden nature of matter, energy, space, and time. The availability of technologies that can explore directly an energy regime known as the Terascale is especially exciting. The direct exploration of the Terascale could be the next important step toward resolving questions that human beings have asked for millennia: What are the origins of mass? Can the basic forces of nature be unified? How did the universe begin? How will it evolve in the future? Moreover, at Terascale energies, formerly separate questions in cosmology and particle physics become connected, bridging the sciences of the very large and the very small in the quest to reveal the hidden nature of space and time. **Recommendations:** • The results of the committee's analysis have led to its chief recommendation. **The United States should remain globally competitive in elementary particle physics by playing a leading role in the worldwide effort to aggressively study Terascale physics.** • To implement the committee's chief recommendation, the Department of Energy and the National Science Foundation should work together to achieve the following objectives in priority order: • Fully exploit the opportunities afforded by the construction of the Large Hadron Collider (LHC) at the European Center for Nuclear Research (CERN). • Plan and initiate a comprehensive program to become the world-leading center for research and development on the science and technology of a linear collider, and do what is necessary to mount a compelling bid to build the proposed International Linear Collider on U.S. soil. • Expand the program in particle astrophysics and pursue an internationally coordinated, staged program in neutrino physics. **Availability:** www.nap.edu/catalog/11641.html

Recommendations to the Department of Energy and the National Science Foundation on a U.S. Program of Reactor- and Accelerator-based Neutrino Oscillation Experiments ***DOE/NSF Nuclear Science Advisory Committee***	**Scope:** NuSAG, the Neutrino Scientific Assessment Group, has been charged by the High Energy Physics Advisory Panel and the Nuclear Science Advisory Committee of the Department of Energy and National Science Foundation "to make recommendations on the specific experiments that should form part of the broad U.S. neutrino science program." One of the charges, dealing with a program in neutrino-less double beta decay, was the subject of NuSAG's first report. The experiments before NuSAG under the remaining two charges, both of which are addressed in this report, are proposals for U.S. participation in the next phase of the worldwide program in neutrino oscillations. This program includes both accelerator- and reactor-based experiments, and its goal is the complete exploration of three-neutrino mixing. **Findings** The worldwide program to study neutrino oscillations is in progress. The U.S. has been a major participant in this from the beginning, and is currently at the forefront, with running experiments that will bring the next major results. A global planning effort has developed a comprehensive set of proposed measurements that together have the potential to fully determine the mixing matrix that parametrizes 3-neutrino mixing The experiments before NuSAG are the first phase of a program designed to perform all of these measurements, subject only to the limitation imposed by $\sin^2 2\theta_{13}$. Accelerator and reactor experiments play complementary roles in this comprehensive study of neutrino mixing, and currently proposed reactor- and accelerator-based experiments have similar reach in sensitivity to oscillations. Construction of experiments in the next round of the global program has begun: in Japan, on a new accelerator-based neutrino beam aimed at the existing Super-K detector (T2K), and in France on an improved reactor experiment (Double Chooz). The U.S. has the opportunity to share the leading role in the global effort with Japan, both by mounting critical experiments and by playing a major role in experiments abroad. The Double Chooz and T2K experiments now under construction will extend the sensitivity to non-zero $\sin^2 2\theta_{13}$ by factors of six and 20, respectively. However, they will be unable to. observe CP violation or determine the mass hierarchy, and, even if *e*ν disappearance or $\nu_\mu \rightarrow \nu_e$ oscillation is seen, would be unable to determine the value of $\sin^2 2\theta_{13}$ precisely or resolve the two-fold ambiguity in θ_{23}. Even if the beam power in T2K is increased, there is only limited potential for observing CP violation and none for determining the mass hierarchy. The NOvA and Braidwood or Daya Bay experiments could bring all of these capabilities for a substantial range of the unknown parameters. observe CP violation or determine the mass hierarchy, and, even if *e*ν disappearance or $\nu_\mu \rightarrow \nu_e$ oscillation is seen, would be unable to determine the value of $\sin^2 2\theta_{13}$ precisely or resolve the two-fold ambiguity in θ_{23}

The neutrino oscillation program can proceed step-by-step. Accelerator-based experiments re-use an existing large detector (T2K with Super-K) and neutrino beam (NOvA with the NuMI beam), each of which represents an enormous investment. First-round observations would indicate if and how beams or detectors should be upgraded. While additional sensitivity is possible with upgraded accelerator beams and detectors, the reactor proposals already push systematic errors using all the tricks they can muster, and no second phase for them is anticipated.

Recommendations:

6.1 General recommendations

6.1.1 The United States can and should be a leader of the worldwide experimental program in neutrino oscillations.

6.1.2 The U.S. program should include both accelerator- and reactor-based experiments.

6.2 Recommendations on accelerator-based experiments

6.2.1 The U.S. should conduct the NOvA experiment at Fermilab. The first phase of this experiment can compete successfully with the Japanese T2K program. If justified by Phase-1 results, both NOvA and T2K have potential later phases. The combination of the two programs is considerably more powerful than either alone, due to their different baselines. Particularly notable is NOvA's sensitivity to the mass hierarchy, unique among the experiments studied for this report.

6.2.2 The U.S. should continue to play an important role in the Japanese neutrino program. This is a cost-effective element of the U.S. program and beneficial to the worldwide program. The U.S. participation in the T2K program should focus in the short term on the B280 effort. This is crucial to bringing the T2K experiment on line. The T2K 2KM project brings improved systematics that would be necessary in later phases of the T2K program. In the initial oscillation search, it would bolster confidence in an observation, especially if NOvA were not underway. U.S. participation on an appropriate time scale is supported if possible.

6.2.3 The U.S. R&D program in Liquid Argon TPC's should be supported at a level that can establish if the technology is scalable to the 10-30 kiloton range. If workable, this technology will come into its own in the later phases of the long-baseline program.

6.3 Recommendations on reactor experiments

6.3.1 The United States should mount one multi-detector reactor experiment sensitive to e disappearance down to $\sin^2 2\theta_{13} \sim 0.01$.

6.3.2 Braidwood and Daya Bay have both made a good case that they could achieve the desired sensitivity, given their current level of technical maturity. The Braidwood experiment has somewhat more sensitivity due to the reduced systematic limitations associated with its simpler geometry. NuSAG did not carry out any detailed review of the costs presented by the two collaborations. Based on the information given us, the Braidwood estimate is further developed than Daya Bay's. It is likely that the cost sharing between the U.S. and China will lead to a lower cost to the U.S. program for Daya Bay. However, until this cost sharing is better defined, it is impossible to determine the relative cost of the two experiments. Understanding that such a determination is necessary, NuSAG strongly recommends that this happen as quickly as possible, with timely R&D funding to further understanding of costs and schedules.

6.3.3 Although it cannot perform its measurements to the sensitivity required by the broader program and thus has lower scientific priority than the larger reactor experiment, U.S. participation in Double Chooz is encouraged because of its relatively low cost and the opportunity to make early improvements in sensitivity to e disappearance.

Availability: www.sc.doe.gov/henp/np/nsac/nsac.html

	Directorate for Mathematical and Physical Sciences (MPS)
Report of the HEPAP Subpanel on the Assessment of Advanced Accelerator Research and Development ***High Energy Physics Advisory Panel (HEPAP)***	**Scope:** The EPP2010 report from the National Research Council highlighted the importance of accelerators and accelerator R&D as a critical element of a world-competitive US particle physics program. Recognizing this importance, the DOE Office of High Energy Physics (OHEP) and the NSF Directorate of Mathematical and Physical Sciences charged the HEPAP Subpanel on Advanced Accelerator R&D to undertake a comprehensive assessment of all aspects of the OHEP and NSF accelerator R&D programs, addressing issues of relevance to national goals, stewardship, scope, quality, relevance, resources, management and training. **Findings** The remarkable discoveries over more than 50 years of particle physics were made possible because of progress and innovation in accelerator science and technology. Today, accelerators are also critical to other programs in the Office of Science and the national scientific enterprise, and they can significantly impact the economy, health, and security. The future of accelerator-based science and applications will be limited unless new ideas and new accelerator directions are developed. Likewise, the demands for trained accelerator professionals far exceed what can be provided by today's limited educational opportunities. The subpanel finds that there is an urgent need to strengthen accelerator science, technology and education in the US in order to address long-term needs of particle physics, other sciences and the nation. **Recommendations:** The subpanel endorses the importance of this stewardship responsibility and recommends that the mission statement of OHEP should be modified to include the following: "The Office of High Energy Physics (OHEP) provides program planning, oversight and funding for research in fundamental accelerator science and technology. The subpanel recommends that APPI [NSF Accelerator Physics and Physics Instrumentation] should be established and funded. The subpanel recommends that an Accelerator Science Graduate Fellowship program in the DOE and NSF should be given high priority. The subpanel recommends that this accelerator science support be protected at both the agencies and the laboratories to maintain stable levels of funding. The subpanel also recommends that the percentage of the OHEP budget assigned for long-term accelerator science should be 5% in FY07, and increased gradually and smoothly to 6% over the next ten year period. To strengthen the management of medium and long-term accelerator R&D in OHEP, the subpanel recommends that these programs be subject to a yearly review by a broad-based committee of accelerator scientists, including members who are cognizant of the possible longer-term accelerator needs of the other Office of Science and NSF programs. This committee should be appointed with overlapping terms to assure continuity. **Availability:** www.er.doe.gov/hep/hepap_reports.shtm

	Directorate for Mathematical and Physical Sciences (MPS)
Workshop on Building Strong Academic Chemistry Departments Through Gender Equity	**Scope:** A large percentage of the potential science, engineering, and mathematics workforce, consisting of women and underrepresented minorities, remains untapped. It is in the best interests of the U.S. to ensure that the workforce be filled with the best talent available. To begin to address these concerns, officials of the National Science Foundation (NSF), Department of Energy (DOE), and National Institutes of Health (NIH) approached leaders of the chemistry community with the idea of bringing together the chairs of the major research-oriented academic chemistry departments. A year of planning by academic leaders and government agency representatives culminated in a workshop titled "Building Strong Academic Chemistry Departments through Gender Equity." Participants included 55 chemistry department chairs and/or representatives from the major research universities and 60 other academic, government, and national chemistry leaders. The workshop, held from January 29 to January 31, 2006, in Arlington, Virginia, began by examining the underlying causes of the gender gap in chemistry departments throughout the country, proceeded through several breakout sessions that discussed and analyzed these factors, and concluded with a set of specific recommendations for action to remedy the problem. Participation by the agency directors responsible for research support for chemistry and department chairs ensured that the people responsible for the future of academic chemistry could participate in coming to a consensus about the nature of the problem and the way toward a solution. **Recommendations to funding agencies:** A key role can be played by funding agencies, whose resources and broad overview can optimize the coordination, calibration, and monitoring of procedures to ensure gender equity in the awarding of research grants. *Develop policies to ensure gender equity in proposal review through:* • instituting procedures for training of reviewers and grantees on diversity issues • modifications of peer review processes where necessary to ensure gender equity • securing Title IX compliance by accumulating data and tracking, as in NSF's ADVANCE programs, including surveys of lab space and resources • fostering gender equity in highly visible Federal programs such as national labs, large research centers, and prestigious awards **Availability:** www.chem.harvard.edu/groups/friend/GenderEquityWorkshop/GenderEquity.pdf