IGERT

INTEGRATIVE GRADUATE
EDUCATION AND
RESEARCH TRAINEESHIP

2006-2007
ANNUAL REPORT

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ACKNOWLEDGMENTS

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IGERT AT-A-GLANCE

The Integrative Graduate Education and Research Traineeship (IGERT) program is the National Science Foundation's (NSF) flagship interdisciplinary graduate training program and has been in the vanguard for the last decade in stimulating a new paradigm in graduate education. The touchstones for summarizing information regarding the program are the NSF Strategic Plan and the IGERT Solicitation, the latter of which states that *"IGERT was developed to meet the challenges of educating U.S. Ph.D. scientists and engineers who will pursue careers in research and education, with the interdisciplinary backgrounds, deep knowledge in chosen disciplines, and technical, professional and personal skills to become, in their own careers, leaders and creative agents for change. The program is intended to catalyze a cultural change in graduate education, for students, faculty, and institutions, by establishing innovative new models for graduate education and training in a fertile environment for collaborative research that transcends traditional disciplinary boundaries. It is also intended to facilitate diversity in student participation and preparation, and to contribute to a world-class, broadly inclusive, and globally engaged science and engineering workforce."*

BACKGROUND AND OVERVIEW

Program inception: 1998

Location at NSF: Division of Graduate Education in the Education and Human Resources Directorate

Number and types of IGERT competitions: One preliminary proposal competition and one invitational competition per year. Approximately 450 preliminary proposals; ~100 invited to submit full proposals and ~20 awards.

IGERT meetings: IGERT holds two meetings per year: One Principal Investigator's (PI) meeting each spring and one new PI orientation meeting in the fall.

NSF IGERT oversight and governance: The IGERT program is overseen by the IGERT Coordinating Committee (ICC) composed of representatives from each NSF directorate and IGERT program officers in the Division of Graduate Education (DGE).

IGERT funding: IGERT is funded through allocations from all Directorates of the NSF and some offices.

Directorates for Biological Sciences (BIO)
Computer and Information Science and Engineering (CISE)
Education and Human Resources (EHR)
Engineering (ENG)
Geosciences (GEO)
Mathematical and Physical Sciences (MPS)

Social, Behavioral, and Economic Sciences (SBE)
Office of Polar Programs (OPP)
Office of International Science and Engineering (OISE)

Number of IGERT grants awarded since program inception: 195 awards

Number of IGERT trainees over all 195 grants to date: 4,232 trainees

Distribution of IGERT grants by state: 40 states plus the District of Columbia have a total of 195 IGERT grants. Thirty (15%) of the grants to date are located in 15 Experimental Program to Stimulate Competitive Research (EPSCoR) states.

Institution distribution for the 195 IGERT grants since inception:

96 institutions

46 institutions have had 1 grant
25 institutions have had 2 grants
10 institutions have had 3 grants
9 institutions have had 4 grants
4 institutions have had 5 grants
1 institution has had 6 grants
1 institution has had 7 grants

IGERT partner institutions:
18 institutions have been a partner on one occasion, 3 have been partner institutions three times, for a total of 21 partner institutions and 27 different partnerships.

International funding: IGERT PIs have the option of requesting funds for the opportunity for trainees to participate in international experiences. 84 IGERTs of the 195 have received additional funding for the international component.

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- Number of IGERT grants reporting in 2007: 136

- Number of IGERT grants awarded in 2007: 20

- The IGERT Coordinating Committee (ICC) names and directorate alignment for the 2006-2007 reporting period are:

BIO: Judy Skog; Anita Klein
CISE: Ken Whang; Sirin Tekinay
EHR: Roosevelt Johnson;
    Dan Maki
ENG: Cynthia Ekstein;
    Scott Midkiff

GEO: Barbara Ransom;
    Lina Patino
MPS: Dean Evasius;
    Uma Venkateswaran
OPP: Fae Korsmo;
    Martin Jeffries
SBE: Pat White; Rita Teutonico
OISE: Rick Nader
BFA: Pamela Green
EHR: Carol Van Hartesveldt;
    IGERT Program Officer
    and ICC Co-Chair;
    Judith Giordan;
    IGERT Program Officer
SBE: Frank Scioli; ICC Co-chair

- All IGERTs are based on interdisciplinary research themes that cut across all directorates. The percentage* of thematic alignments as identified by the PIs of the 136 IGERTS reporting in 2006-2007 with the NSF directorates:

60% align with BIO
52% align with ENG
42% align with MPS
37% align with SBE
31% align with CISE
18% align with GEO
1% align with OPP

*   *Due to the interdisciplinary nature of the research, percentages will not add to 100.*

TRAINEES 2006-2007

- Number of trainees funded during the 2006-2007 reporting year: 1,519 trainees

- Number of trainees graduated with a Ph.D. during the 2006-2007 reporting year: 154 trainees

TRAINEE QUALITY

In the 2006-2007 annual survey, PIs were asked to compare the quality of their IGERT trainees to their other graduate students. 95% of IGERT PIs rated IGERT trainees as superior or better than their usual graduate students.

EXECUTIVE SUMMARY

The goal of this report is to provide to the stakeholders and community of the IGERT program an overview snapshot and a better understanding of the IGERT program overall through the lens of the compiled annual reports of the individual IGERTs active in 2006-2007. The report summarizes the input of the 136 individual IGERT project annual reports for the 2006-2007 collection period submitted on the web-based reporting system for IGERT. As a purely descriptive report, no recommendations for the program's future or evaluative conclusions are drawn.

Report Framework and Results Overview

The IGERT Solicitation acts as the basis for the many unique aspects of the IGERT program and the NSF strategic plan forms the framework in which the IGERT solicitation operates. For the NSF strategic goal of discovery, IGERT generates cutting edge interdisciplinary research that transforms landscapes of scientific understanding from unidimensional to multidimensional, advances scientific knowledge, and links interdisciplinary research with innovative interdisciplinary education to create a unique and well-rounded interdisciplinary graduate training experience. For the NSF strategic goal of learning, IGERT works diligently to ensure broadened participation across underrepresented groups in science, technology, engineering, mathematics (STEM) disciplines; supports the public's better understanding of science and technology; reaches out to K-12 students and undergraduates in order to help bridge critical educational junctures; and ensures that IGERT trainees have a global perspective and are prepared for 21st century careers.

Topics for summation were derived using the IGERT Solicitation and NSF Strategic Plan as the guidelines. (See Appendix 1) The topics aim at addressing four key points of importance in both the IGERT Solicitation and NSF Strategic Plan:

1. Transformative research achievements and discoveries based on cutting-edge interdisciplinary science, technology, engineering, and math.

2. Innovative interdisciplinary graduate education with curricular options, courses, interactions, and partnerships, including methodologies for developing trainees with the technical, professional, and personal skills to become leaders and creative agents for change in a globally engaged science and engineering workforce.

3. Informing the general public, undergraduates, and K-12 students about the innovative science in IGERTs.

4. Broadening participation in STEM graduate education.

Summary of Selected Highlights from Each Topic

1. Transformative research achievements and discoveries based on cutting-edge interdisciplinary science, technology, engineering, and math. The 136 IGERT projects submitting annual reports in 2006-2007 reported a total of 335 distinct research achievements— defined as accomplishments of significant impact.

- The achievements reported pertain to the interdisciplinary research of each IGERT and cut across all the Directorates of the NSF. Overall, the validation of these achievements, in academic terms, resulted in a total of 811 journal publications; 345 conference publications; 1,171 conference presentations; 52 book chapters and 14 books; 31 patents; and 61 patent applications.

- The interdisciplinary themes of the 136 reporting IGERTs cut across critical research invest-ment areas including sustain-ability, the environment and ecology; computational science and engineering, applied and

interdisciplinary math; human and social dimensions of new science and technology; nanoscience engineering and technology; energy, with a focus on alternate and renewable sources and conservation; materials science and engineering; bioinformatics; civil infrastructure monitoring and improvement; entrepreneurialism; neuroscience – biology and psychology; climate changes, impacts and factors; biological evolution and development; diverse device development; and sensing, signals and signal processing – engineering math and science.

2. Innovative interdisciplinary graduate education with curricular options, courses, interactions, and partnerships, including methodologies for developing trainees with the technical, professional, and personal skills to become leaders and creative agents for change in a globally engaged science and engineering workforce.

- One-hundred twenty-two (122) of the 136 IGERTs reported 328 educational achievements for their IGERTs directly addressing developing new degrees and unique courses, workshops and seminars for trainees and other university students.[1]

- One-hundred sixteen (116) of the 136 IGERTs have reported prior industrial and governmental partners or collaborations; 21 (18.1%) reported active

ties in 2006-2007 with industry ranging from industrial provision of facilities for research, research collaborations, and exchange of personnel.

- Thirty-nine (39) (33.6%) of the 116 IGERTs reporting active partnerships or collaborations in 2006-2007 report having partnerships with nonindustrial organizations including government labs and agencies, universities, foreign entities, and nonprofit organizations.

- Forty-three (43) (31.6%) of the 136 reporting IGERTs described 82 different funded international experiences, and a total of 98 IGERTS (72.1%) reported some type of international activity in the 2006-2007 reporting year. International activities range in scope from internships in foreign countries, to volunteer activities, to presentations at international conferences, and research.

3. Informing the general public, undergraduates and K-12 students on the innovative science in IGERTs.

- Through outreach activities, 68 IGERTs reported a total of 175 instances of involvement with K-12 and 20 IGERTs reported 44 instances of involvement with undergraduates.

- IGERTs reported 688 instances of outreach to groups including government, local organizations, industry, and the general public. Activities ranged from radio and television interviews to websites, lectures, field trips,

and museum presentations and exhibits.

4. Broadening participation in STEM graduate education.

- One-thousand five-hundred nineteen (1,519) trainees were funded in 2006-2007 by the IGERT program overall across 136 active IGERTs.

- One-hundred fifty-four (154) trainees received their doctoral degrees through the 136 active IGERTs reporting in 2006-2007 (84 males, 65 females, 5 whose gender was not reported. Nine were underrepresented minorities.)

- When IGERT PIs were asked to compare the quality of their IGERT trainees to their other graduate students, 95% of PIs rated their IGERT trainees as superior or better than their usual graduate students.

- Overall, for race/ethnicity IGERTs exceed national data for 52% of all fields; are equal to national data for 38% of all fields; and are only slightly behind national data in 10% of all fields.

- For females, when broken down by field, IGERT is engaging more females into nontraditional fields for the gender. IGERTs exceeded national data for females in 79% of fields and were slightly lower in 21% of fields.

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[1] Note: Not all IGERTs necessarily report educational achievements in every year. Some IGERTs are newly starting and others are in a no-cost extension, and thus may not have new educational achievements to report.
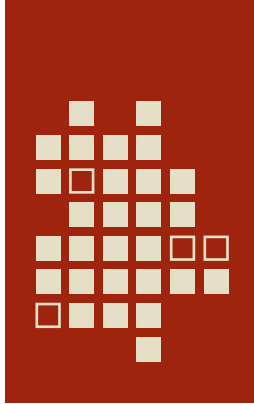
CHAPTER 1

Transformative Interdisciplinary Research Achievements

The National Science Foundation must support the most innovative and potentially transformative research, research that has the capacity to revolutionize existing fields, create new sub fields, cause paradigm shifts, support discovery, and lead to radically new technologies... The Foundation must create an environment that is more open to and encourages transformative research proposals from the research community.

— National Science Board, 2020 Vision for the National Science Foundation, 2005

"Discovery increasingly requires the expertise of individuals with different perspectives—from different disciplines.... working together to accommodate the extraordinary complexity of today's science and engineering challenges."[1] With this as a starting point, all IGERTs address the NSF strategic outcome of Discovery and all of its five sub-goals.

Promoting Transformational and Multidisciplinary Research

All IGERTs promote transformational and multidisciplinary research. The 136 IGERT projects submitting annual reports in 2006-2007 reported a total of 335 distinct research achievements. These achievements are defined as accomplishments of significant impact of the projects as pertains to the interdisciplinary research of each IGERT and cut across all the Directorates of the NSF. Overall, the objective indicators of these achievements are a total of 811 journal publications, 345 conference publications, 1,171 conference presentations, 52 book chapters and 14 books.

Further U.S. Economic Competitiveness

Of the 136 IGERT projects submitting annual reports in 2006-2007, 13% directly involve aspects of entrepreneurialism and 18.1% have formal industry interactions. 35 patents and 61 patent applications arose from IGERT interdisciplinary research across a wide variety of fields and topics.

The remainder of this chapter summarizes each of the technology themes as reported by all IGERTs for year 2006-2007 both qualitatively (with examples) and quantitatively (in terms of counts and percentages reporting) and relates them to NSF's

NSF Strategic Outcome: Discovery

Foster research that will advance the frontiers of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering.

strategic plan and IGERT's solicitation. Table 1 summarizes the breadth of the IGERT thematic experience in terms of both the number and percentage of IGERTs involved with a given theme, and academic achievements associated with the research themes of the IGERT.

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[1] National Science Foundation. (2006.) Investing in America's Future. Strategic Plan, FY 2006-2011. NSF Publication Number 06-48.

Table 1: Breadth of Thematic Experiences and Academic Achievements

TOPICS	# IGERTS	% IGERTS	# Journal Articles	# Conference Publications	# Conference Presentations	# Book Chapters	# Books
Sustainability: ecology and the environment	38	28	211	58	313	7	4
Computational science and engineering	48	35	188	110	252	18	1
Human and social dimensions of new knowledge and technology	44	32	188	72	403	26	6
Nanoscience: engineering and technology	23	17	188	87	254	6	4
Energy: alternate and renewable resources and conservation	4	3	21	6	12	0	1
Materials science and engineering	27	20	219	101	200	4	3
Bioinformatics	11	8	62	3	57	0	1
Civil infrastructure monitoring and improvement	2	1	36	2	45	2	0
Entrepreneurialism	17	13	109	93	181	5	3
Neuroscience: biology and psychology	10	7	24	14	55	2	0
Climate change: impacts and factors	6	4	55	27	116	2	0
Biological evolution and development	11	8	58	33	88	7	0
Diverse device development	24	17	123	56	108	8	3
Sensing, signals, imaging and signal processing	14	10	83	55	107	9	2

Sustainability: Ecology and the Environment

Thirty-eight (38) of the 136 IGERTs reporting in 2006-2007 address the NSF strategic investment goal of discovery, fostering research that improves our ability to live sustainably on earth. Examples of projects that strengthen our understanding of the links between human actions and natural processes range from developing a knowledge base for policy creation and decision making to restoring wetlands that were formerly part of a U.S. Army base.

The interdisciplinary skills involved with the training in these IGERTs are setting the platform for developing a new cadre of scientists and engineers conversant both in science and its communication and societal impacts. The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ Openlands, a Chicago area conservation group, invited an IGERT project to participate in the restoration and management of a lakefront preserve on the former Fort Sheridan Army base including more than one mile of undeveloped Lake Michigan shoreline and one of the last remaining bluff/ravine ecosystems in Illinois. (0549245: Ashley, University of Illinois Chicago)

☐ Working in conjunction with Ceres, a Boston-based nongovernmental organization (NGO), during an internship, an IGERT trainee worked to form a relationship between U.S. financial management/corporate organizations and the U.S. Congress to aid in developing a suite of national policies to mitigate carbon emissions into the atmosphere. (0504103: August, University of Rhode Island)

☐ By integrating several sources of social-ecological sustainability theory, one IGERT is developing new participatory methods for engaging local indigenous communities on research in ways Alaska and other such environments can enhance the sustainability of various human-impacted systems. (0114423: Chapin, University of Alaska Fairbanks)

☐ A publication resulting from an IGERT summer course involved collaborations among ecologists, engineers, and chemists. It demonstrated that micro-organisms use chemical means to compete with macro-organisms, that this may significantly affect energy and nutrient flow, and that microbes need to be considered as competitors with large animals in marine food webs. This unification of the disciplines of chemistry, microbiology, food-web theory, and ecosystem level processes was broadly covered by the press — including the journal *Nature*, and various radio, web, and print based media. (0114400: Hay, Georgia Tech Research Corporation - GIT)

☐ While studying the transport of toxic heavy metals in Clark Fork River, IGERT researchers discovered that heavy metal containing mineral nanoparticles, not previously known to exist in river systems, appeared to be responsible for transporting lead, copper, zinc, and arsenic down river hundreds of miles from the source of the initial contamination. (0504196: Hochella, Virginia Polytechnic Institute & State University)

☐ An IGERT student had the opportunity to study molybdenum isotopes during an international internship to Lake Tanganyika in Tanzania. The lake, with oxygenated surface waters and sulfidic bottom waters, provided a unique system for testing her hypothesis that molybdenum isotopes behave differently depending on whether or not the overlying water has sulfide present. She sampled sedimentary deposits in the lake's freshwater system for comparison with the marine environment. The results to date suggest that molybdenum isotopes may be useful for quantifying carbon flux through time. (0114427: Myrold, Oregon State University)

Computational Science and Engineering: Applied and Interdisciplinary Mathematics

Forty-eight (48) of the 136 IGERTs reporting in 2006-2007 addressed the NSF strategic investment priority of advancing fundamental research in computational science and engineering, and in fundamental, applied and interdisciplinary mathematics and statistics. From linguistics to interactive digital media to assessing changes in coastal ecosystems, IGERT projects have developed and used computational tools to further our knowledge in a range of research covering all NSF Directorates.

The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ A team of four trainees with backgrounds in microbiology, ecology, math and computer science performed a collaborative study that integrates global information system (GIS) data, climate change models, and on-the-ground presence data for plague to predict how current models of climate change will affect the distribution of plague in the U.S. in the future. Preliminary results suggest that the range of distribution will likely shrink. (0504628: Holben, University of Montana)

☐ An "open channel" protocol for email was proposed and investigated and conditions were discovered under which offering such a channel in parallel to a spam-filtered "closed channel" would reduce the total amount of spam sent and increase the quality of commercial advertising information conveyed in spam, thus benefiting both senders and receivers of spam advertising. (0114368: Mackie-Mason, University of Michigan)

☐ A collaboration of geology, industrial and system engineering IGERT trainees and faculty developed an ontology on natural disaster effects and responses that would improve decision-support and information interoperability between emergency responders. The specific case study was focused on the October 2006 snow storm in Erie County New York and used cognitive systems engineering methods and the philosophical notion of ontology to conceptualize work flow and information flow. (0333417: Mark, State University of New York Buffalo)

☐ Novel media systems for interactive rehabilitation are under development. The systems integrate task specific motor skill training, associated sensory and cognitive stimuli, and stress monitoring within interactive, multimodal environments. The environments provide purposeful, engaging audiovisual scenes in which stroke survivors practice functional movement tasks, while receiving multimodal feedback indicating measures of performance and results, promoting neural plasticity and encouraging improvement. The system was successfully tested this year with three stroke patients, each patient undergoing six training sessions with the system. Initial results show that the system has strong potential to increase functional recovery of patients. Developing this system requires interdisciplinary interaction to integrate sophisticated information analysis, sensing and feedback systems and medical technologies (team includes 14 members spanning these disciplines). (0504647: Rikakis, Arizona State University)

☐ The integration of mathematical linguistics and theoretical linguistics via an IGERT-developed computational track has shown how the general properties of neural network self-organization can explain

pervasive patterns found in the inventories of vowels and syllables in the world's languages. (0549379: Smolensky, Johns Hopkins University)

☐ An IGERT trainee is developing a high-spatial/temporal numerical model for simulating the hydrody-namics in the lower Mississippi River. High resolution unstructured finite element mesh of the Bird's Foot Delta in the Lower Mississippi River Delta using the Surface Water Modeling Software (SMS) has been developed. The intent is to develop new methods of visualization and hydrodynamic modeling of saltwater intrusion. (0504507: Acharya, Louisiana State University & A&M College)

Human and Social Dimensions of New Knowledge and Technology

Forty-four (44) of the 136 IGERTs reporting in 2006-2007 directly address the human and social dimensions of new knowledge and technology, a strategic goal of the NSF. The range of the research from the impact of toxic wastes in streams to the socioeconomic modeling of crop planting and its impact on maintaining biodiversity to contributions to our understanding of HIV/AIDS spread under conditions of rapid economic and social change gives a glimpse into the breadth of the IGERT trainee research and training experience. Trainees and their mentors address fundamental challenges faced by humans and the planet resulting from the ever changing landscape of human interaction with science and technology.

Table 1 summarizes the number of journal articles, conference publications, conference presentations, book chapters and books reported by IGERTs associated with human and social dimensions of new knowledge and technology in 2006-2007. Examples of the research achievements of the 44 IGERTs involved with human dimensions of science and technology include:

☐ New methods have been developed and tested for monitoring and motivating people recovering from stroke using cameras and computer vision technology to measure movement characteristics in stroke survivors in the home. The work has resulted in methods for aiding patients to regain greater strength more quickly after experi-encing strokes. (0333420: Atkeson, Carnegie Mellon University)

☐ Trainees working in Idaho's conifer forests developed simula-tions to explore the implications of present and future residential patterns and forest thinning based on landowner and stakeholder interviews and shared their results with land managers and decision makers in the region. (0114304: Bosque-Perez, University of Idaho)

☐ Two books: *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools and Societies* by Scott Page and *Complex Adaptive Systems: An Introduction to Compu-tational Models of Social Life* by John Miller and Scott Page contributed substantially to our understanding of human dynamics and social systems. (0221611: Page, University of Michigan)

☐ Research on security and intellectual property issues associ-ated with synthetic biology has found that intellectual property conflicts and the lack of a U.S. research exemption threaten development of the field. This work has led to collaboration with Department of Homeland Security contractors assessing screening systems for DNA synthesis orders. (0333010: Hastings, Massachusetts Institute of Technology)

Many plants that invade natural areas were introduced as garden ornamentals; our 2003 cohort studied the role of the horticultural trade in establishing invasive species. In a telephone survey of 54 nursery professionals, trainees found that 100% of respondents thought that invasive species pose a problem; 80% thought that nurseries contribute to the spread of invasives; but 83% had not heard of voluntary codes of conduct developed by industry professionals in collaboration with researchers, with the goal of reducing the spread of invasive plants through nurseries. Voluntary initiatives have become increasingly popular as an alternative to government regulation, but may be less effective in an industry that lacks centralized control. Open access of the publication has led to its posting on the U.S. Department of Agriculture (USDA) website, as well as on the web pages of the Center for Invasive Plant Management, and the Great Plains Noxious and Invasive Weeds. (0114432: Strauss, University of California Davis)

In a series of papers it has been shown that complexity is a serious obstacle to both efficiency and equity in the distribution of student aid, disproportionately burdening those with the least ability to pay. These results have been covered in the *New York Times*, the *Chronicle of Higher Education*, and other news media. (0333403: Wilson, Harvard University)

Nanoscience Engineering and Technology

Twenty-three (23) of the 136 IGERTs reporting in 2006-2007 directly address the breadth and interdisciplinary nature inherent in nanoscience engineering and its application technology to help further U.S. economic competitiveness. IGERTs on topics ranging from developing fundamental understanding of nanostructures to using this knowledge to improve manufacturing processes to help move nanotechnologies to aid U.S. economic competitiveness and address the America Competes Initiative are all within the scope of the IGERTs in this theme.
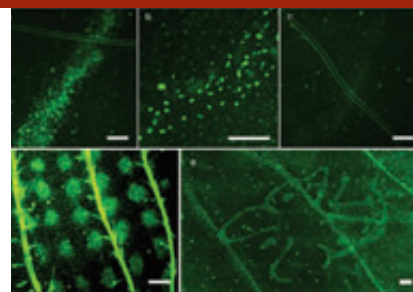
The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

Plasmonic properties of metallic nanostructures using dark-field microspectroscopy are being investigated for a wide range of nanostructures, including nanoshell dimers, nanorice (prolate-spheriodal nanoshells), and nanoholes in a gold film. This work includes studying the polarization-dependent microspectroscopy of an individual nanoshell dimer compared with a nanoshell monomer. This ability to see the dependence of a structure's spectrum on the polarization orientation is invaluable for characterization of the plasmonic properties of nanostructures. (0504425: Halas, William Marsh Rice University)

An interdisciplinary team demonstrated continuous-flow production of small gold nanoparticles in a simple microcapillary system. Production rates are at least a gram/hour (>10 times higher than batch) and waste is reduced by a factor of 10. While the system and method have not been optimized, this is an impressive result that is a significant step toward high-volume production of nanoparticles. The final experiments are underway and a manuscript is being drafted. The work is the result of a multi-institution collaboration between chemists and engineers. (0549503: Johnson, University of Oregon Eugene)

☐ A project on nanoparticle photovoltaics involved the development of the first reported quantum dot sensitized nanowire solar cell, based on CdSe nanocrystals attached to an array of ZnO nanowires. After incident photons are absorbed by the nanocrystals, electrons are transferred into the ZnO nanowires, while the holes travel in a hole conductor to the opposite terminal of the solar cell. This solar cell improves on another low-cost solar cell, the so called dye-sensitized cell, in two ways: First, it replaces the light-absorbing organic dye, which has stability issues on long-term exposure to light, with more stable, inorganic quantum dots. Second, it uses an array of nanowires for the electron transport instead of a network of abutted nanoparticles with frequent, inhibiting grain boundaries. This project involves four IGERT students and five faculty members from three different fields: Chemistry, Chemical Engineering and Materials Science, and Mechanical Engineering. (0114372: Kortshagen, University of Minnesota Twin Cities)

☐ A dual magnetic resonance/optical detectable nanoprobe capable of reaching medulloblastoma (MB) tumors behind the blood brain barrier has been developed. During thorough testing it was shown to be capable of selectively binding MB cells and enable delineation of tumor boundaries through MR and optical imaging. (0504573: Olmstead, University of Washington)

☐ Interdisciplinary work involving several labs has demonstrated for the first time that an electric field used to macroscopically align polymer nanofibers (300 nm diameter) can also align polymer chains parallel to the fiber axis. This important result indicates that anisotropic structural properties (mechanical, electrical, etc.) can be induced in polymer nanofibers during the electrospinning process. Such uniaxially oriented nanofibers exhibit a variety of potential applications in biomedicine, microelectronics and optics. A simple technique of vertical electrospinning with electric field induced, stationary collection was employed to obtain the molecular orientation in polymer nanofibers. (0221651: Robinson, University of Delaware)

☐ An IGERT trainee used quantum dots to image the distribution of T cell receptors (TCRs) on T cell surfaces in vivo. This newly developed technique relies on the stochastic "blinking" of single quantum dots to determine the clustering of TCRs following the activation of a T cell by antigen exposure. Previously, it had been shown in vitro and by indirect methods that, following activation, TCRs cluster together to form larger patches on the surface, which increases the sensitivity of TCRs and, hence, T cells to antigens. The research allows for visualizing this process in vivo, tagging TCRs with conjugated IgG molecules, and using biotinylated quantum dots as a secondary antibody. Using this method the clustering of TCRs in activated T cells, as well as the subsequent "deactivation" or declustering of TCRs which occurs in the absence of continuous stimuli, were observed. (0549350: Stebe, Johns Hopkins University)

Energy: Alternate and Renewable Resources and Conservation

Four (4) of the 136 IGERTs are directly related to the production of alternate energy sources and the concomitant basic science and engineering required for their successful implementation. Addressing NSF strategic priorities of fostering research to improve our ability to live sustainably on earth coupled with improving our economic competitiveness, these IGERTs range from solar energy to wind energy to fuel cell improvement. Their interdisciplinary success is further interwoven with elements of nanotechnology and cutting edge material science.

The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ IGERT trainees have been involved in the potential applications for solar hydrogen and the way in which limited surface area places a premium on achieving high efficiency photovoltaics (PV). An approach to high efficiency PV is to use nano-structured materials, such as quantum dots, to allow efficiencies above that of a single junction. By developing band structure models for nanostructured solar cells, our IGERT students from across the disciplines have identified materials which can be used to achieve >50% thermodynamic efficiencies by using GaAsSb/InAs barrier/dot material systems. (0549399: Honsberg, University of Delaware)

☐ Low temperature polymer electrolyte membrane (PEM) fuel cells suffer from their dependence on water. Water is required in order to reach peak proton conductivity of the membrane, but too much water can result in liquid water formation in unwanted regions. A full under-standing of the behavior of water within the various portions of the fuel cell must be understood in order to balance these two effects.

Researchers (mechanical engineers, electrochemists, physicists) have performed direct in-situ water distribution measurements in the membrane, electrodes, and gas diffusion layers using neutron imaging. These measurements are the first of their kind and are being used to test the few existing hydration-conductivity theories, some of which have been relied on for decades by the fuel cell commu-nity. (0504361: Jensen, Rensselaer Polytechnic Institute)

☐ A computational framework for multiscale modeling of the thermal degradation of lubricating oils was developed. Multiscale models of lubricant degradation connect atomic-level details such as elemen-tary reaction rates to macroscopic properties of lubricant degradation such as the "total acid number" or "oxidation induction time." The key pieces of the model include a system-atic methodology for producing structure-reactivity relationships from quantum chemistry and transition-state theory and reaction. These new models are helping to unravel the complex reaction mechanisms that govern lubricant

degradation, and a consistent picture of the dominant reaction pathways involved is emerging. Furthermore, this new simulation framework has been extended to incorporate the action of free-radical scavenging antioxidants such as hindered phenols. Students from Chemistry, Chemical and Biological Engineering, and Mechanical Engineering have all contributed to this project. (0114429: Keer, Northwestern University)

☐ Hourly-averaged data from the wind-center research center's 200m tower is used to examine static atmospheric stability as a governor of speed and direction shear during day time and night time hours in the atmospheric boundary layer. Large magnitudes of direction shear are found to occur concurrently with wind speed greater than 8 m/s. Joint probability distributions of speed and direction shear measured at Lubbock, Texas show, through numerical simulation, that power loss can be 0.5%. Over the 20-year lifetime of a 100 MW wind power plant this translates to a $3.5 million loss in project revenue.(0221688: Mehta, Texas Tech University)

Materials Science and Engineering

Twenty-seven (27) of the 136 IGERT projects reporting in 2006-2007 address the broad aspects from discovery to development of new materials with potential applications that range from oxygen sensors to materials for super-capacitors—from the nanoscale to macroscale. All of these projects address the NSF strategic investment priority of discovery in promoting transformational, interdisciplinary research and fostering U.S. economic competitiveness.
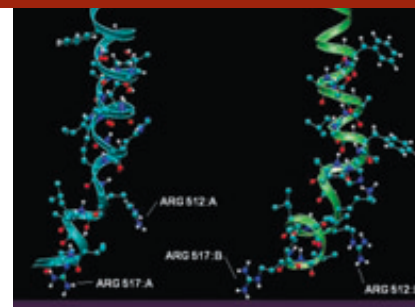
The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ An IGERT team developed new materials for oxygen sensing by sequestering the luminophore tris(4,7-diphenyl-1,10-phenanthro-line)ruthenium(II) ([Ru(dpp)(3)](2+)) within hybrid xerogels that are composed of two of the following methoxysilanes: tetramethoxysilane, n-propyl-trimethoxysilane, 3,3,3-trifluoropropyl-trimethoxysilane, phenethyl-trimethoxysilane, and pentafluorophenylpropyl-trimethoxysilane. Steady-state
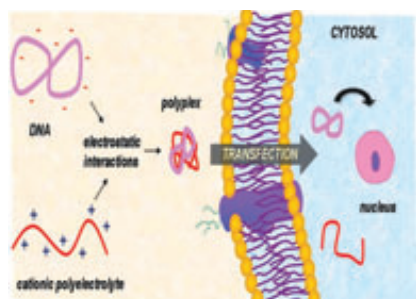
and time-resolved luminescence measurements were used to investigate these hybrid xerogel-based sensor materials and elucidate the reasons for the observed performance. These composites form visually uniform, crack-free xerogel films that can be used to construct oxygen sensors that have linear calibration

curves and excellent long-term stability. The [Ru(dpp)(3)](2+)-doped fluorinated hybrid xerogels exhibit the highest oxygen sensitivity of any reported [Ru(dpp)(3)](2+)-based sensor platform. (0114330: Cartwright, State University of New York Buffalo)

☐ IGERT trainees and faculty from engineering and chemistry have demonstrated the effect on nano-scale polymer thin film properties of coordinative crosslinking. The result offers the possibility for very fine control of nanoscale mechanics, building on related work on the macroscale already completed. (0221632: Clark, Duke University)

☐ An IGERT trainee and colleagues in the United States and France published the first paper in *Science* magazine related to supercapacitors (anamolous increase in carbon capacitance at pore sizes less than 1 nanometer). The work deals with the design of porous carbon mate-rial which can be used as electrodes in supercapacitors. Historically, the design protocol for supercapacitor carbons was to produce the largest surface area with the largest pore

size possible. According to this work, however, decreasing the electrode pores below 1 nm can lead to smaller, lighter, more powerful supercapacitor devices. (0221664: Gogotsi, Drexel University)

☐ IGERT researchers are spear-heading the development of powerful new "metrology" of cell-biomaterial interactions. Traditional methods study cell properties on only one or a few biomaterials at a time, which is inefficient and qualitative. The Rutgers IGERT "Cell Profiling Tool-Box" quantifies cellular processes simultaneously on multiple materials. (i) Large libraries of biomaterials are created with differing chemical and mechanical properties. (ii) Cells are engineered with living fluorescent reporters whose organization changes upon cell contact with a biomaterial. (iii) Image analysis, with additional computer modeling and bioinfor-matics, correlates the fluorescent images to biomaterial properties and cell functions. Information thus generated can help accelerate the design of improved biomaterials targeting important applications,

such as control of stem cell differentiation toward specific lineages (bone, cancer). (0333196: Moghe, Rutgers University New Brunswick)

☐ One IGERT has focused on the design of small particles that carry imaging agents to developing heart disease plaque, and trainees have successfully formulated and delivered microparticles containing magnetic resonance imaging agents to plaques likely to cause complications in order to more clearly picture the areas

using magnetic resonance imaging (MRI). The ultimate goal is to impact personalized patient care. (0333080: Peppas, University of Texas Austin)

☐ By developing and subsequently utilizing a novel resonant-cavity-enhanced absorption technique, record cooling temperatures and cooling power in a crystalline solid have been achieved. This has paved the way for attaining the ultimate goal of cryogenic temperature operation of solid-state laser cooling.

Led by an IGERT trainee, the research involved multidisciplinary teams from our University of New Mexico's Center for High Technology Materials (involving IGERT faculty participants), Los Alamos National Laboratory, and a crystal growth group from Italy. The research achievement itself will have broader impact as it will be applicable to high-sensitivity spectroscopy and detection of chemical and biological systems. (0114319: Rudolph, University of New Mexico)

Bioinformatics

Eleven (11) of the 136 IGERTs reporting in 2006-2007 address the inherently interdisciplinary field of bioinformatics. By combining computational skills with data set analysis, IGERT trainees are developing unique skills that can impact everything from our ability to live sustainably on earth to advancing fundamental computational computer science, as trainees and IGERT faculty strive to push the limits of algorithm development and utilization.

The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ Interdisciplinary teams of IGERT trainees and associates developed a synthetic understanding of the wildlife management issues surrounding population dynamics of elephants and their impacts on the ecological and social fabric of the Okavango Delta watershed during the summer program in Africa. Students developed a series of simulation models that tested hypotheses regarding the causes and effects of increased elephant populations. The models show long-term trends about which local wildlife and natural resource

managers could only speculate but now can communicate to local populations the underlying causes of increased elephant numbers and the effects on local economies. The multidisciplinary approach explored diverse aspects of the elephant population explosion, including effects on tourism and economies, impacts of increased salinization from elephant damage to trees, competition with other grazers, and interactions with livestock livelihood systems. (0504422: Brown, University of Florida)

☐ A trainee-organized research project: Does exclusion of random error alter model inference? A case study using grizzly bears (*Ursus arctos*) of the Greater Yellowstone Ecosystem (GYE) resulted in a study on the effects of including error source terms on model selection and inference in population dynamics. The team used both frequentist and Bayesian model selection approaches to investigate the effect of errors on the inferences made from population data. The results of the analysis show that expanding models to include error

terms leads to more robust decisions about delisting of the GYE grizzly bears (*Ursus arctos*) from the Endangered Species list. (0221595: Davis, Colorado State University)

☐ An IGERT trainee in conjunction with IGERT faculty is developing mathematical models for within-host dynamics of three infections: (i) influenza, (ii) Streptococcus pneumoniae, and (iii) influenza followed by S. pneumoniae. Using experimental data, the team is quantifying infection parameters, investigating treatment strategies, and testing mechanisms of interaction between influenza and S. pneumoniae and each of their interactions with the immune system. (0217424: Keener, University of Utah)

☐ Three IGERT trainees, each from a different department (Ecology and Evolutionary Biology, Plant Sciences, and Computer Science) formed a collaboration on a research project several years ago that explored the relationship between rates of protein evolution and gene expression evolution in Drosophila. They discovered a positive correlation between rates of protein evolution and rates of expression divergence. By testing for evidence of positive selection, they showed that the correlation between expression and protein divergence is probably due to underlying variation in the level of selective constraint, challenging a widely held view in the field. (0114420: Nachman, University of Arizona)

☐ The program, Development and Release of Garli: A genetic algorithm for phylogenetic inference using maximum likelihood criteria is a result of several years of collaborations between biologists and computer scientists for an IGERT. The program uses a genetic algorithm to solve a difficult computational program of interest to many biologists: the phylogenetic analysis of trees of many thousands of DNA sequences, under a model-based maximum likelihood criterion. This program cuts analysis time by at least 10-fold over previous programs. The final program was written by an IGERT trainee with input from many IGERT faculty and trainees. The program is available for free download at http://www.zo.utexas.edu/faculty/antisense/garli/Garli.html. It has quickly become the primary program used by biologists around the world for phylogenetic analysis under maximum likelihood. (0114387: Hillis, University of Texas Austin)

Civil Infrastructure: Monitoring and Improvement

Two (2) of the 136 IGERTs reporting in 2006-2007 directly address infrastructure monitoring from aspects of engineering, corrosion science, and computational modeling, all aimed at improving our understanding of the lifetime, usage and reliability of materials. The interdisciplinary theme addresses NSF discovery strategic investment priorities of promoting transformational and interdisciplinary research and improving our ability to live sustainably on earth.
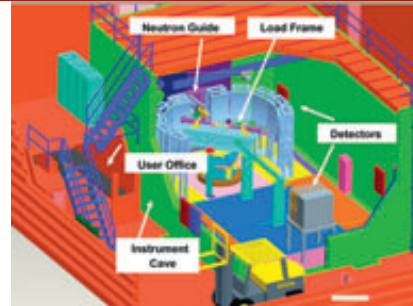
The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ A new multidisciplinary research group named Systems Health Monitoring was formed, bringing together the disciplines of civil engineering and computer science. This effort is leading to the transfer of computer engineering fault detection methods to mechanical and multidisciplinary systems in aerospace vehicles, and is a new extension of the IGERT research theme not envisioned earlier, but made possible due to the interdisciplinary teamwork. (0114329: Mahadevan, Vanderbilt University)

☐ By studying the resistance of Haynes C2000 to corrosion in both static and mechanically-dynamic conditions and comparing the findings with nano nickel-based materials and bulk metallic glasses, a refined model was proposed to predict the lifetime of the nickel-based materials subjected to corrosion fatigue. In addition, nano Ni-Fe and Ni-Co materials were studied to gain insight about their corrosion behavior. (9987548:Liaw, University of Tennessee Knoxville)

Neuroscience: Biology and Psychology

Ten (10) of the 136 IGERTs reporting in 2006-2007 addressed the interdisciplinary theme of neuroscience. Involving statistics, computational science, neuroscience, imaging, and psychology, these projects have led to discoveries from visual imaging to mechanisms of contextual decision making. The theme addresses many of the discovery intensive NSF strategic investment priorities, including promoting transformational interdisciplinary research and advancing research in math and applied statistics.

The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ An IGERT trainee at the University of California, San Diego's Vision and Learning in Humans and Machines IGERT discovered that Bayesian optimal experimental design principles could be used to design informative experiments to help reveal the intuitive value of information. The work is helping to clarify what information people believe to be most informative on a variety of learning tasks. One such

task is categorization. Other relevant tasks include scientific hypothesis testing and medical diagnosis. In every case, information is not inherently valuable, but valuable as a function of the probabilities in the world it helps a person learn what they need to carry out a task. (0333451: de Sa, University of California San Diego)

☐ An IGERT trainee has been working on an interdisciplinary project involving statistics and neuroscience. The goal of the project is to develop an algorithm for optimizing data collection during neurophysiology experiments. Since neural systems are highly-dimensional, complex systems, each experiment typically provides only a little information regarding the hypothesis or question to be answered. By modifying the design of the experiments as data are collected, one can potentially conduct more pertinent experiments based on the hypothesis. The algorithm combines ideas from information theory, control theory, and compu-tational neuroscience. Simulations show that the algorithm collects information more efficiently than traditional random experimental design. The algorithm is also efficient enough to work in high-dimensional real time applications. (0333411: DeWeerth, Georgia Tech Research Corporation-GIT)

☐ The Science of Learning: This interdisciplinary collaboration between faculty and students in psychology, neurosciences, cell biology and physiology, computer

science and engineering, and geology is a direct result of the IGERT activities. The team is studying the connections among human development, learning, memory, thinking, attention, motor skills, etc. Of particular interest is perceptual motor skill development as a new paradigm for learning abilities and disabilities. (0504438: Flach, Wright State University)
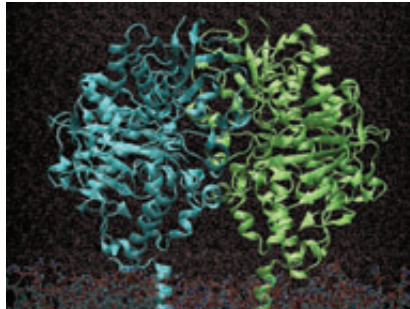
☐ To address the goal of enabling direct comparison of human and monkey neuroimaging experi-ments, an IGERT has developed computer hardware and software and modified the monkey imaging setup so that monkey experiments parallel human experiments as well as having developed new stimulus presentation equipment so mon-keys experience the same visual stimuli as humans. Technologies needed to begin our novel monkey neuroimaging to parallel human studies have been established. Comparisons with monkey neuro-physiology will provide novel insights into how individual neuronal activity underlies func-tional brain imaging. (0548890: Thoroughman, Washington University School of Medicine)

☐ IGERT trainees and faculty have used functional neuroimaging to shed light on an important perceptual puzzle: despite constantly changing images on the retina as the eyes move, the world appears still. It was shown that voxels in the right hemisphere, which encode the initial retinal location of a stimulus, are active prior to eye movement, but when the eyes move, voxels in the left parietal cortex become active even though no physical stimulus ever appeared in the right visual field. This demonstrates "spatial updating" in human parietal cortex. New Bayesian statistical methods were developed to assess this updating. It was discovered that updating is present even in the earliest stages of processing, indicating that motor signals from eye movement commands are used throughout the visual system as part of the circuit that keeps the world still. (9987588: Touretzky, Carnegie Mellon University)

☐ An IGERT trainee has begun to develop a mathematical model of real-time sentence comprehension to simulate some of the online eye movement results from a psycho-linguistic experiment recently completed. Simulations are being done within the framework of the interdisciplinary coursework developed by the IGERT. (0504487: Trueswell, University of Pennsylvania)

Climate Change: Impacts and Factors

Six (6) of the 136 IGERT projects reporting in 2006-2007 directly address climate change, ranging from its impact on tree species survival to developing data-based scales to measuring the intensity of tornadoes. Each IGERT in this area directly addresses the NSF strategic investment priority of fostering interdisciplinary research to improve our ability to live sustainably on earth.

The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ An IGERT trainee studied the response of northern hardwood tree species to atmospheric carbon dioxide and nitrogen (N) deposition. The research was conducted to determine how these global change factors might impact future forest functioning. Results indicated that N deposition and atmospheric carbon dioxide (CO_2) will interact to influence understory seedling survival and plants exposed to elevated CO_2 and high N deposition had the greatest survival rates (among the plants studied). Results also indicate that CO_2, N deposition and understory light availability will interact and strongly impact symbiotic arbuscular mycorrhizal fungi associations. It was concluded that increases in atmospheric CO_2 and reactive N deposition will enhance seedling photosynthesis and survival in N-limited temperate forests because seedlings will use these atmospheric compounds as additional plant resources. (0504552: Carroll, University of Michigan)

☐ Faculty and trainees of an IGERT have developed the Enhanced Fujita (EF) scale to rate intensity of tornadoes. IGERT students provided input to this project by using it and validating it in the field for wind storm damage documentation and analysis. Meteorologists and engineers developed 26 damage indicators of buildings and structures. Each damage indicator is divided into several Degrees of Damage (DOD). An expert panel was used to assign wind speed to each DOD to cause that damage. The EF-scale was reviewed through several National Weather Service (NWS) committees. After developing training material for operational personnel, the EF-scale to rate intensity of tornadoes was implemented by the NWS beginning February 2007. (0221688: Mehta, Texas Tech University)

☐ A major focus of another IGERT is the reconstruction of past climate and environments utilizing Tree Ring Research, that has been at the center of a recent National Academies report warning that long-term patterns of variation in the Colorado River basin raise concerns for continued urban growth in the states that depend on Colorado River water. (0221594: Olsen, University of Arizona)

☐ An IGERT trainee presented at the 2007 American Geophysical Union (AGU) Joint Assembly in Mexico on her work assessing the usefulness of the cosmogenic isotope beryllium-10 as a proxy for solar irradiance changes. By using the Goddard Institute for Space Studies Model E general circulation model, she is working to develop a better understanding of how climate-related and production-related changes in the isotope record can be calibrated to solar climate forcings. (0221041: Polvani, Columbia University)

☐ A recently graduated IGERT trainee is beginning a congressional internship on climate change issues and alternate energy based on her IGERT experience in freshwater sciences. (9972810: Ward, University of Alabama Tuscaloosa)

Biological Evolution and Development

Eleven (11) of the 136 IGERTs reporting in 2006-2007 address the theme of evolution and development covering a wide range of disciplines and approaches to solving the riddle of how inhabiting species exist, develop, and evolve on this planet. The theme addressed the discovery NSF strategic investment priorities of transformational, interdisciplinary research and fostering our ability to live sustainably on earth.

The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ An interdisciplinary project at the fossil hominin site of Laetoli in Tanzania represents one of the most comprehensive studies of an African paleoanthropological site. The international team includes more than 40 scientists from Africa, Europe, and the United States, with expertise in paleontology, geology, palynology, botany, and ecology. The main goals of the project are to recover additional fossil hominins and to better understand their geological and paleoecological context. These data have provided an important building block in a broader understanding of habitat diversity, climate change, and macroevolutionary models in relation to human evolution in East Africa. (0333415: Delson, City University of New York Graduate School)

☐ IGERT trainees have published research demonstrating that fish extinctions impact nutrient recycling in tropical streams and lakes. They combined field data from Lake Tanganyika, Africa, and Venezuelan streams with modeling to examine the impact of fishing removal of major species on nutrient cycling. In both of these species-rich ecosystems, recycling was dominated by relatively few species, but contributions of individual species differed between nitrogen and phosphorus. Alternative extinction scenarios produced widely divergent patterns. These results are the first to demonstrate the effect of fish species extinctions or manipulations on nutrient processes in this kind of environment, and have important implications for managing fresh-water tropical fisheries. (0221658: Derry, Cornell University)

☐ IGERT trainees and faculty have shown the first direct evidence that social bonds have adaptive value for female baboons. Using behavioral and genetic records from the Amboseli Baboon Research Project, they demonstrated that female baboons form close, equitable, and stable social bonds with a small number of preferred partners. Females rely on kin for support in agonistic interactions as well as for more peaceful forms of affiliation. The most sociable females reproduce more successfully. This finding linking social behavior directly to reproductive outcomes provides the most compelling evidence to date that social bonds have adaptive value for nonhuman primates. These results provide a striking parallel to evidence on humans which indicates that social support has beneficial effects on health and well-being across the lifespan. (0504228: Peplau, University of California Los Angeles)

☐ Integrative research from one IGERT is making an impact outside of the evolutionary development world as well. Research by one of the IGERT trainees produced the first genetic linkage map, and identified the first photoperiodic timer quantitative trait loci (QTLs) for any organism. The work is part of a broader research program to understand the evolutionary consequences of global climate change. (0504627: Postlethwait, University of Oregon Eugene)

☐ An IGERT trainee is combining ecology and fracture mechanics to address the form/function relationships between the size and shape of the teeth and the nature of the foods eaten by certain animals. A unique hypothesis has been developed to explain the relationship between the thickness and microstructure of enamel and the nature of the foods processed. (9987590: Wood, George Washington University)

Further U.S. Economic Competitiveness: Diverse Device Development

Twenty-four (24) of the 136 IGERTs directly address the synthesis of interdisciplinary training ranging from chemistry, to biology, materials science, and engineering for developing devices ranging from novel drug delivery to the development of femto-second lasers and mini-spectrometers in the tera-hertz time domain. This area of inherently interdisciplinary research helps to aid our economic competitiveness and to investigate the human and social dimensions of science and technology as it allows us to gain information never before available.

The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ Novel ways to prepare polymeric vesicles for controlled drug delivery and gene therapy are under development via collaborations of biologists and polymer scientists. It has been found that it is possible to prepare vesicular structures by using alternating copolymers of maleimide and vinyl ether monomers. Upon hydration, vesicles form spontaneously. These are on the average <50 nm in diameter and will soon be used to transfect mammalian cell lines with plasmid DNA. Cells will be transfected with pDNA coding for green fluorescent protein and transfection efficacy will be analyzed via fluorescent microscopy. (0333377: Fried, University of Cincinnati)

☐ A lab-on-a-chip platform was developed in which liquids are manipulated as droplets on a two-dimensional array, rather than as streams in channels. Students from mechanical engineering and chemistry interacted and identified research problems that subsequently benefited from their combined expertise. These include understanding and facilitating droplet mixing, developing strategies for separating charged particles within a single droplet, and reducing friction by controlling device surface roughness (superhydrophobicity). Success was also achieved in implementing chemical processing functions, such as crystallizations, liquid-liquid extractions, solid-phase extractions, and enzymatic digestions in the devices. (0114443: Garrell, University of California Los Angeles)

☐ An IGERT trainee co-advised by a faculty team with backgrounds in physics and chemistry successfully demonstrated fabrication of waveguides in 3D using femtosecond lasers. These waveguides can be used for interconnection between optical devices. Another IGERT student successfully demonstrated fabrication of quantum dots by etching of quantum well structures for optical switching applications. Progress in optical communications and networking requires breakthroughs at the fundamental device level. Future optical networks will feature more processing in the optical domain. The ability to realize functional devices and interconnect between the devices is critical. (0114418: Li, University of Central Florida)

☐ A group of interdisciplinary scientists and engineers led by an IGERT trainee developed miniature terahertz time domain spectrometer systems for sensing and imaging. These devices require both extensive knowledge and working experience across multiple disciplines. This team developed the "Mini-Z" THz spectrometer which is dramatically smaller and lighter than any previous terahertz time-domain spectroscopic device, and it already has proven its ability to detect cracks in space shuttle foam, measure chemical, biological agents, and explosives and their related compounds. The device, which weighs less than five pounds and fits snugly in a briefcase, could open the door to a wide range of applications in homeland security, biomedical imaging, and nondestructive testing of industrial components. (0333314: Wang, Rensselaer Polytechnic Institute)

☐ Peptide arrays are under development to use as chemical libraries to search for catalysts and for components of artificial antibodies in an approach very similar to the chemistry performed in the DNA chip industry. This approach allows for rational peptide design and synthesis, hundreds of thousands of peptides at a time. An IGERT trainee recently created an array with all possible 6-mers using a set of five amino acids and is exploring the binding of these 6-mers to specific proteins. This array promises to provide a fundamental understanding of molecular recognition properties of short peptides. (0114434: Woodbury, Arizona State University)

Sensing, Signals, Imaging and Signal Processing

Fourteen (14) of the 136 IGERTs reporting in 2006-2007 are involved with the sensing and processing of signals and images. With the need for greater detailed understanding of ever smaller images with greater amounts of information, IGERTs involved with signal processing are transforming our ability to hear and touch and move more effectively to the ability to sense pathogens and hazards. The NSF strategic investment priorities of promoting transformational, interdisciplinary science; fostering our ability to live sustainably on earth; investigating the human and social dimensions of science and technology; and helping the U.S. be more competitive are all addressed in this thematic area of discovery.

The publications and conference presentations associated with this theme are in Table 1. Examples of the research achievements include:

☐ Optical Science and Engineering Program (OSEP)/IGERT trainees along with their advisors have developed the world's first optoelectronic analog statistical signal processor. The system solves what is popularly referred to as the "cocktail party problem," which refers to the human ability to pay attention to one voice among many despite the presence of noise and other interfering signals. The solution to the problem calls for the descrambling of mixed signals with little or no prior knowledge about the signals or how they are mixed. The human brain seems to do this effortlessly but, when done by machine, it involves a computationally intensive statistical analysis of the incoming signals. Using a creative synthesis of holography, electronics, and nonlinear dynamics, the researchers have developed a system whose dynamics are mediated by input signal statistics in such a way that the system automatically unscrambles incoming mixed audio or radio-frequency signals. (0333453: Anderson, University of Colorado Boulder)

☐ An IGERT trainee has made an important advance in the goal of providing a microarray-based sensor for rapid identification of pathogens by demonstrating, in collaboration with scientists at the National Institutes of Health as well as IGERT faculty in chemistry and chemical engineering, that his research on the modification of surfaces with light can be used to identify immunogenic sugar moieties of *Bacillus anthracis* exosporium by designing and fabricating carbohydrate microarrays. Working with this interdisciplinary team, the trainee created the first method for covalently bonding carbohydrates to surfaces that does not require modification of the carbohydrates. (0221589: Denn, City University of New York City College)

☐ Collaborators in mathematics and mechanical and aerospace engineering have been investigating sensory motor integration in dexterity. The dexterity of individuals is tested as they compress a weak spring that is prone to buckling. Theoretical insights from dynamical systems theory are used to predict aspects of the observed behavior at the threshold for buckling. The experiment is repeated with vision blocked, with tactile sensation blocked and with both vision and tactile sensation blocked. The observed performance gives insight into the way in which sensory information of different modalities is combined in manipulation. This work won the 2006 *Journal of Biomechanics* Award of the American Society for Biomechanics. (0333366: Guckenheimer, Cornell University)

☐ Collaboration among four disciplines is leading to the development of an implantable technology to restore balance. This combines expertise in head and neck surgery, MEMS, and signal processing. This project and collaboration was a direct result of the LifeChips/IGERT sponsored workshop for Head and Neck to bring new collaborations to LifeChips. This collaboration fulfills one of the goals of this IGERT—to initiate new interdisciplinary collaborations in LifeChips research that also provide student training opportunities. (0549479: Li, University of California Irvine)
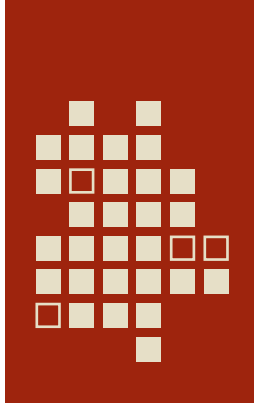
CHAPTER 2

Transformative Achievements in Education – IGERT Trainees

The integration of cutting edge research and education provided by all IGERT programs is the epitome of the NSF vision of "advancing discovery, innovation and education beyond the frontiers of current knowledge, and empowering future generations in science and engineering."

— NSF Strategic Plan

The NSF strategic outcome centered around learning with its six investment priorities forms the foundation for both the IGERT solicitation and the information collected in the annual reports of all IGERT projects as applied to education. Indeed, at the heart of IGERT are two of the sub-goals of the NSF goal of learning: integrating research and education to build capacity and to prepare a diverse and globally engaged STEM workforce.

- One-hundred twenty-two (122) of the 136 IGERTS reported 328 educational achievements for their IGERTs directly addressing the sub-goals in the form of new degrees and unique courses, workshops, and seminars for trainees and other university students. New degrees, certificates, and courses are a result of the integration of research with education in which the interdisciplinary nature of the research calls for new paradigms in education, and are summarized in Table 2.

- Tables 3-5 summarize the range of training in communication preparation, preparation to conduct research, and developing professional skills applicable to careers in industry, government, or the private sector.

- Two-hundred four (204) trainees reported internship experiences. Of 116 IGERTs that have reported industrial and governmental partners or collaborations in the past, 21 (18.1%) reported active ties in 2006-2007 with industry ranging from industrial provision of facilities for research, research collaborations, and exchange of personnel. Thirty-nine (39) (33.6%) of the 116 IGERTS reporting active partnerships or collaborations in 2006-2007 report having partnerships with nonindustrial organizations including government labs and agencies, universities, foreign entities, and nonprofit organizations.

- Of the 136 IGERTs reporting in 2006-2007, 43 (31.6%) have reported a total of 82 international experiences.

The IGERT program is intended to catalyze a cultural change in graduate education for students, faculty, and institutions by establishing innovative new models for graduate education and training in a fertile environment for collaborative research that transcends traditional disciplinary boundaries. It is also intended to facilitate diversity in student participation and preparation, and to contribute to a world-class, broadly inclusive, and globally engaged science and engineering workforce.

IGERT Solicitation

The remainder of this chapter will provide detailed information on:

- Evidence for the integration of research and education
- Training preparation for communicating their STEM research and experiences
- Career preparation experience
- Preparation to conduct research
- International experiences

The examples will describe how the reporting 136 IGERT projects for 2006-2007 have addressed the investment priorities as described for learning in both the NSF Strategic Plan and the IGERT Solicitation: integrating research with education; forming partnerships with industry, government and nongovernment organizations; and preparing a global workforce.

NSF Investment Priority: Integrate Research with Education and Build Capacity
Graduate courses, seminars, workshops, new degree and certificate programs from IGERT

One-hundred twenty-two (122) of the 136 IGERTs submitting an annual report in 2006-2007 (89.7%) reported 328 educational achievements including new courses, seminars, degree programs, and certificate programs. (See Table 2.) Many of these educational achievements were developed by IGERT trainees.

Table 2: New Courses, Degrees, Certificates, Workshops, Seminars, Conferences & # Trainees Involved With Course Development

# New courses	# New degrees or certificates	# Workshops, seminars, conferences	# Trainees reporting involvement with course development
80	16	81	573

Examples of the integration of research and education include:

☐ An IGERT developed new courses to integrate nanostructure fabrications, atomic scale characterizations, and materials theory into a cohesive interdisciplinary research program about the interfaces and defects that play an important role in the performance of modern electronics. The courses were required for trainees but open to all graduate students, exposing many students to interdisciplinary research. The courses included nanostructure characterization techniques, theory of inorganic nanostructures for device applications, and ethics. (0549417: Shih, University of Texas Austin)

☐ Two new courses were developed to train students to investigate biological systems spanning wide temporal and spatial scales from atoms and macromolecules to cells, organs, and organisms. These courses require facility in applied mathematics and computer science. The courses are a bioinformatics course that pairs computer science and math students with biologists, and a statistical analysis of genomic data course that enrolls computational biology, computer science, math, and biology graduate students. (0333389: Shelley, New York University)

☐ A new doctoral degree curriculum has been established in Wind

Science and Engineering to produce professionals who, through careful planning, effective public policies, and good engineering, may be able to reduce losses caused by hurricanes, tornadoes, and other violent storms. Graduate students will take courses in meteorology, engineering, system theories, economics/risk management, GIS, statistics, and leadership/ethics with a 4-month external lab rotation. (0221688: Mehta, Texas Tech University)

☐ The combination of interdisciplinary science education with entrepreneurial and business training on how polymer science and medicinal chemistry can synergistically extend the methods of making and evaluating new materials, new bioactive agents, and new applications of biomaterials is so successful that the University of Southern Mississippi now offers a graduate minor in Technology Commercialization and the collaborating University of Mississippi offers the same program as a certificate. (0333136: Wicks, University of Southern Mississippi)

☐ Access to a wide range of researchers in the field of nanoparticles is made available to trainees through a seminar offered by an IGERT with a research focus on nanoparticle science and engineering that addresses the development of enabling computational and characterization tools that will form the foundation for research in application-oriented areas focusing on new materials, devices, and the environment. In addition to this opportunity to develop leadership skills interacting with leading scientists in the field, trainees also participated in a symposium with the Industrial Partnership for Research in Interfacial and Materials Engineering (Iprime) consortium, developing communication skills by giving oral and poster presentations to visitors from industry and academia. (0114372: Kortshagen, University of Minnesota Twin Cities)

☐ Through an interdisciplinary program on optical science and engineering, trainees entered the Colorado Photonics Industry Association Poster Competition. Trainees attended the annual poster exhibit and learned about the latest in photonics research. Trainees also attended an optics seminar, where a diverse array of speakers from industry, academe and business furthered the trainees' global and interdisciplinary education. (0333453: Anderson, University of Colorado Boulder)

NSF Investment Priority: Prepare a Diverse and Globally Engaged STEM Workforce

Professional preparation in communication, skills to conduct high quality research, and skills applicable to careers in government or the private sector

Table 3 summarizes the extent to which IGERT trainees have had the opportunity to gain skills in various methods for communicating science and technology. Numbers are "number of trainees" out of 1,519 reporting a given experience in the 2006-2007 reporting year.

Table 3: Professional Preparation in Communicating Science and Technology

Training and coursework in professional writing	Training and/or coursework in professional speaking and/or presentation skills	Presentation made at the IGERT institution	Professional conferences attended	Poster sessions and/or presentations outside the IGERT institution	Oral presentations outside the IGERT institution
324	430	1,032	1,018	676	705
21.3%	28.3%	67.9%	67.0%	44.5%	46.4%

Table 4 illustrates the range of skill to which IGERT trainees have been exposed to examples of the breadth of training required to conduct high quality research. Data are "number of trainees" reporting for each theme.

Table 4: Professional Skills to Conduct High Quality Research

Training/coursework in responsible conduct of research	Training/coursework in research methods	Training/coursework in state-of-the-art instrumentation	Participation in research projects within your own discipline area but outside your dissertation research
572	581	555	793
37.7%	38.2%	36.5%	52.2%

A key part of IGERT is to give graduate students uniquely trained in transformational interdisciplinary research the opportunity to gain professional skills to help them use their scientific training across a broad range of career options. Table 5 summarizes examples of such experiences for IGERT trainees in 2006-2007.

Table 5: Professional Skills Applicable to Careers in Industry, Government, or the Private Sector

Participation in any interaction between academic research and industrial applications or between academic research and public policy development or application	Training/experience in communications across disciplines and with different audiences (including the general public)	Education interactions (e.g., courses, workshops, seminars) with industry professionals or with government or other public-sector professionals	Research interactions (other than internships) with industry professionals or with government or other public-sector professionals
347	563	379	310
22.8%	37.1%	25.0%	20.4%

NSF Investment Priority: Prepare a Diverse and Globally Engaged STEM Workforce
Partnerships and collaborations

One-hundred sixteen (116) of the 136 IGERTs reporting in 2006-2007 indicate collaborative arrangements of various types during the life of the IGERT. Table 6 summarizes the data for active industrial and nonindustrial collaborations for 2006-2007.

Table 6: IGERT Collaboration Arrangements for 2006-2007

# IGERTs with partnerships with industry	# IGERTs with partnerships with nonindustrial organizations
21 (18.1% of 116 reporting IGERTs)	39 (33.6% of 116 reporting IGERTs)

Examples of the efforts of IGERTs in preparing a diverse and globally engaged STEM workforce through partnerships with industry and nonindustrial organizations include:

☐ An industrial partnership with Aptima, a company specializing in solving the problems of human performance in today's complex sociotechnical systems, resulted in trainees conducting collaborative research in the area of computational analysis of social and organizational systems and becoming conversant with the role of scientists in industry. (9972762: Carley, Carnegie Mellon University)

☐ An IGERT that is studying the functioning of regional systems through an integration of the tools and approaches of ecology, economics, anthropology, climate dynamics, and philosophy in a systems framework is partnered with British Petroleum (BP), an industry that operates about half of the oil fields in Prudhoe Bay, Alaska. BP supplies facilities for project activities and BP staff work with IGERT project staff on collaborative research and teaching, as well as supporting the research of a trainee studying the effects of anthropogenic resources on raven distributions. (0114423: Chapin, University of Alaska Fairbanks)

☐ The goal of training a new generation of scientists capable of designing and implementing solutions to environmental problems within the framework of human culture, economics, policy, and the law is closely aligned with the purpose of the Nature Conservancy, a nonprofit organization that works around the world to protect ecologically important land and water. IGERT and the Nature Conservancy are exploring risk assessment and management of Great Lakes invasive species, partnering together to perform collaborative research involving staff and facilities exchanges. (0504495: Feder, Notre Dame)

☐ The facilities of the Los Alamos National Laboratory were utilized for a trainee project involving the synthesis of novel uranium intermetallic compounds and characterization of their electronic properties by magnetic susceptibility, heat capacity, and electrical resistance measurements. The Los Alamos National Laboratory also provides personnel for collaborative research and teaching as well as the use of its facilities in this partnership. (0114443: Garrell, University of California Los Angeles)

☐ A partnership with another Ph.D. granting institution is evidenced in Tuskegee's partnership with Cornell University. The two institutions exchange faculty and students and participate in seminars and meetings to enhance Tuskegee's research and educational capability in the research area of materials science and engineering and to promote an increase in the number of underrepresented graduate students in that field. (0333380: Jeelani, Tuskegee University)

☐ Ecole Polytechnique Federale de Lausanne in Switzerland is an example of a foreign-based partnership with an IGERT at the University of Texas, Austin. This IGERT has a research focus on cellular and molecular imaging for diagnostics and therapeutics. The two institutions collaborate on research and teaching, exchange facilities and staff, and host trainee internships, allowing trainees to experience scientific research with a global perspective. (0333080: Peppas, University of Texas Austin)

Forty-three (43) (31.6%) of the 136 reporting IGERTs described 82 different funded international experiences, and a total of 98 IGERTS (72.1%) reported some type of international activity in the 2006-2007 reporting year. International activities range in scope from internships in foreign countries to volunteer activities to presentations at international conferences to conducting research in other countries.

Examples of international opportunities that help prepare a diverse, globally engaged STEM workforce are:

☐ Research on the impact of conservation measures in Costa Rica resulted in not only an increased understanding of a foreign culture and its language, but the nature of the scientific enterprise in that culture. To aid in better international understanding and cooperation, trainees discussed their research findings with the local communities as well as presenting numerous papers at international meetings. (0114304: Bosque-Perez, University of Idaho)

☐ A 10-month internship for an IGERT trainee at the University of Heidelberg, Germany, resulted in two talks, one to a collaboration of scientists working on understanding biological attachment and another to a European nanotechnology think tank, both about research on the attachment of rat fibroblast to thermal responsive surfaces. This international experience provided the trainee with a global perspective on the practice of science. (0114319: Rudolph, University of New Mexico)

☐ The opportunity to conduct research outside of the United States in the fields of geoscience, physics, tree-ring studies, and materials science in conjunction with archaeological theory and methods, has resulted in a trainee becoming a highly proficient interpreter of sedimentary sequences in cave deposits in Europe and Central Asia. These studies have resulted in an award-winning paper for the "Developing International Geoarchaeology" conference in Cambridge, United Kingdom. (0221594: Olsen, University of Arizona)

☐ All trainees from one IGERT carry out their dissertation research in Latin America on issues relating to the use and conservation of unprotected tropical rain forests, providing them with the opportunity to work closely with indigenous populations, foreign government agencies, universities and other nongovernment organizations. (0221599: Zarin, University of Florida)

☐ IGERT trainees teamed with faculty and students from Sichuan University and the science department staff from Jiuzhaigou National Park in China to conduct research for two weeks on the sanitation and wastewater treatment in the park. This led to research presentations at international conferences and an understanding of the intricacies of scientific research in China. (0333408: Hinckley, University of Washington)

☐ Trainees conducted a survey of sites throughout Malaysia and Borneo to make a qualitative assessment of the conditions of coral reef sites spanning a gradient of forest conversion. The trip allowed the trainees to meet with researchers at Malaysian universities, government and nongovernment agencies, giving them a global perspective on a global problem. (0333444: Knowlton, University of California San Diego Scripps Institute)

☐ An interest in understanding how humans create spatial patterns of vegetation within urban landscapes and how that structure impacts environmental and ecological processes led an IGERT trainee to produce a high resolution urban forest mapping classification scheme for Phoenix, Arizona. This technique has led to collaboration with worldwide scientists for use in other areas of the world and to a publication in the International Journal of Remote Sensing. (0504248: Redman, Arizona State University)

☐ An IGERT trainee attended the Lindau Meeting, an annual, international gathering of Nobel Laureates and young researchers focusing on physiology and medicine. The meeting provided opportunities to network with the most accomplished international scientists in the world. The trainee will also collaborate with the winner of the 1991 Nobel Prize in Medicine and Physiology at the Max Planck Institute to develop new nanoscale imaging and sensing tools and apply them in the investigations of fundamental problems in cell biology and neuroscience. (0549500: Osinski, University of New Mexico)
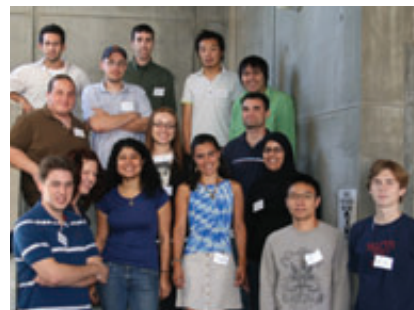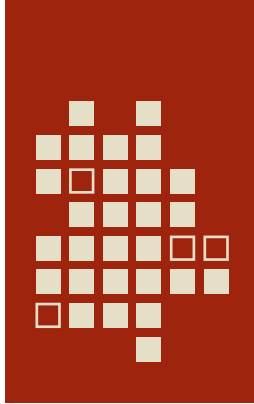
CHAPTER 3

Informing the World –
Influencing STEM Knowledge

The NSF Strategic Plan includes investment priorities in learning which are intended to "Build strong foundations and foster innovation to improve K-12 teaching, learning ...in science and mathematics... Develop methods to effectively bridge critical junctures in STEM education pathways," and "Engage and inform the public in science and engineering through informal education."

— NSF Strategic Plan

Reaching out to the general public, working to help bridge critical junctures in STEM education, and improving K-12 learning in science and mathematics are all ways IGERTs work to influence STEM knowledge.

- Sixty-eight (68) of the reporting 114 IGERTs reported a total of 175 instances of involvement with K-12, and 20 IGERTs of the reporting 114 reported 44 instances of involvement with undergraduates, thereby addressing two sub-goals of learning: building stronger foundations and fostering innovation in K-12 teaching and learning and developing methods to effectively bridge critical junctures in STEM education pathways.

- One-hundred forty (140) grants (some grants were involved in all four outreach activities) report multiple outreach endeavors to nonprofit organizations, government agencies, international entities, and other universities.

- The 114 IGERTs reporting outreach activities in 2006-2007 reported a total of 688 opportunities to reach out to others to explain their research interests and to increase the public's awareness of STEM topics through museums, radio, television and media, lectures, and presentations.

Table 7 summarizes the outreach to K-12 and undergraduates as reported in 2006-2007 over all 136 IGERTs that reported, aligned by the interdisciplinary themes of the IGERT defined in Table 1.

The remainder of this chapter will detail information on outreach to K-12 students and their teachers, undergraduates, the general public, government agencies, industry, organizations and international entities.

NSF will inspire the next generation by promoting excellent science education, including timely access to exhilarating discoveries in classrooms, and by partnering with museums and other organizations that use informal science to bridge the gulf between scientific advances and public understanding.

NSF Strategic Plan

Table 7: Outreach to K-12 and Undergraduate Students by Interdisciplinary Research Themes[2]

TOPICS	# Instances IGERTs involved in K-12 education	# Instances IGERTs involved in undergraduate education
Sustainability: ecology and the environment	51	6
Computational science and engineering	60	18
Human and social dimensions of new knowledge and technology	52	11
Nanoscience: engineering and technology	43	15
Energy: alternate and renewable resources and conservation	5	0
Materials science and engineering	43	24
Bioinformatics	5	4
Civil infrastructure monitoring and improvement	1	0
Entrepreneurialism	15	2
Neuroscience: biology and psychology	19	0
Climate change: impacts and factors	5	1
Biological evolution and development	3	1
Diverse device development	28	8
Sensing, signals, imaging and signal processing	21	11

[2] The number of instances and IGERT grants involved in K-12 and undergraduate education are distributed across interdisciplinary research themes and, thus, will be counted more than once.

Sixty-eight (68) of the 114 IGERTs (59.6%) reporting outreach activities reported 175 such activities involving K-12 students and/or teachers. These educational opportunities run the gamut from laboratory or field experiences for students and teachers outside of the classroom, to lectures and talks, classes or courses taught to students and teachers, mentoring experiences, science fair mentoring and judging, and raising funds for improving K-12 education.

Examples of the educational opportunities of the 68 IGERTs that are involved with K-12 students and/or their teachers include:

☐ Working with teachers and students to develop gardens in the context of traditional Athabascan (native Alaskan) culture, IGERT trainees are educating students about the sustainability of a culture embedded in an ecosystem subject to rapid change. (0114423: Chapin, University of Alaska Fairbanks)

☐ Biological invasions are becoming increasingly common as the result of globalization, but the invasions are only recognizable if the native ecosystem is known. To familiarize students with the ecology of the area in which they live, IGERT trainees take tide pools to K-12 classrooms. (0114432: Strauss, University of California Davis)

☐ IGERT trainees who combine a strong interest in ecology and quantitative methods of modeling ecological resources are also concerned about quality science education for all students. Trainees developed a birding program and walk for students with special needs, thereby improving science education for the students. (0221595: Davis, Colorado State University)

☐ To improve K-12 students' understanding of nanotechnology and stimulate their interest in the study of STEM fields, a Micro/Nano summer Robotics Camp was organized by IGERT personnel. During the camp, students were introduced to the principles of micro- and nanotechnology using LEGOS,® thus engaging students in activities that were appealing and meaningful. (0221681: Bhansali, University of South Florida)

☐ Educating policy makers and the public is one goal of an IGERT researching the degradation and vulnerability of marine ecosystems. To help accomplish this task, trainees give talks to elementary, middle, and high school students about the biology and conservation of marine turtles, local marine organisms, and food webs and wetland conservation. The lectures are designed to help students relate to marine ecosystems and foster a desire to protect them. (0333444: Knowlton, University of California San Diego Scripps Institute)

☐ Increasing the interest of under-represented groups in STEM fields is a priority of NSF, and one IGERT has pursued this goal by presenting a two week summer program at Tuskegee University to introduce high school students from underrepresented groups to college education and scientific research. (0333380: Jeelani, Tuskegee University)

☐ The excitement of new discoveries in the field of plant genomics through the use of computational sciences led an IGERT to share their research with teachers and students in the form of lectures, laboratory experiences, and podcasts during the summer. Teachers and students learned about cutting edge science from the scientists performing the research, a powerful incentive for students. (0504304: Voytas, Iowa State University)

☐ The importance of awakening young children's sense of wonder about the natural world was evident to an IGERT whose research topic is the natural interface science application to environmental science and engineering. A workshop on herbs was presented to kindergarten students in a fun and exciting way to promote their interest in science. (0504196: Hochella, Virginia Polytechnic Institute & State University)

☐ The highly complex science of computational fluid dynamics was shared in the form of a workshop for high school students by one IGERT. The workshop introduced the students to high performance computing and computational fluid dynamics, acquainting students with topics not generally taught in high school science classes and demonstrating the excitement of real-world science. (0504507: Acharya, Louisiana State University & A&M College)

☐ The effect of biogeochemical microorganisms on Earth's environment is the focus of an IGERT that led to the development of a 15-hour class on climate change for tenth and twelfth grade students. Students investigated the science of global warming through basic modeling activities, data analysis, discussion and movies, providing a thorough grounding in a timely science topic. (9972759: Brantley, Pennsylvania State University)

NSF Investment Priority: Develop Methods to Effectively Bridge Critical Junctures in STEM Education Pathways: Undergraduate Scientific and Educational Interactions

Twenty (20) of the 114 grants (17.5%) reporting outreach activities reported 44 activities involving interactions with undergraduate students. IGERT trainees and faculty are working to effectively bridge the critical junctures of undergraduate to graduate training in the STEM pipeline. This is being accomplished by ensuring that a working knowledge of cutting-edge interdisciplinary science and the skills critical for graduate school success are reaching undergraduates.
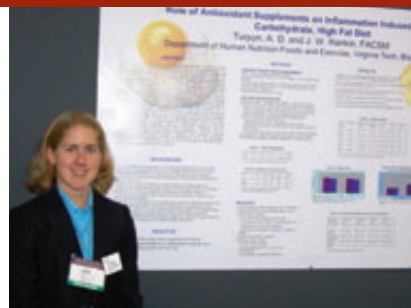
Examples of IGERT efforts to bridge critical junctures in STEM undergraduate to graduate education include:

☐ A new course, "The Challenges of a Complex World," was developed for undergraduates as a result of an award from the University of Michigan Office of the Provost to promote interdisciplinary and team teaching. Students use mathematics, computation, and experimentation to address the biggest challenges of the modern world by learning the fundamental properties of complex adaptive systems as applied to global warming, sustainability, epidemics, terrorism, and the impacts of technology and globalization on the world. (0221611: Page, University of Michigan)

☐ In order to stimulate the interest of undergraduates in economics and provide opportunities to put what they learn into practice in the community, an IGERT trainee founded an undergraduate economics club called SWEET (Students Who Enjoy Economics Thinking). The club sponsors student activities and speakers in economics, as well as conducting community outreach programs to teach free enterprise. (0114423:Chapin, University of Alaska Fairbanks)

☐ Stimulating interest in physics was the purpose of a lecture to undergraduate physics majors in the Passion for Physics course. Undergraduates were also invited to an IGERT trainees' research posters session where they learned about the exciting possibilities of the transformation of future computing and communication systems and biomedical imaging through terahertz research in electronics, data transfer and networking systems, and spectroscopy and imaging. (0333314: Wang, Rensselaer Polytechnic Institute)

☐ Workshops on writing in the sciences were presented by a trainee to Research Experiences for Undergraduates (REU) students, thus promoting undergraduate students' interest in continuing their education in a STEM field. The course included a discussion of the anatomy of an article, timeline for developing a proposal, presentation techniques, and editing strategies. (0221713: Manjunath, University of California Santa Barbara)

☐ Undergraduate students are encouraged to continue their education in STEM fields when they participate in a summer research program introducing the interdisci-plinary research at the interface of nano/micro-technology and life science. Undergraduates are given the opportunity to conduct research while learning about career devel-opment, graduate school, and presentation skills. (0549479: Li, University of California Irvine)

☐ Trainees not only excited undergraduate students about the research in marine biodiversity and the policies that affect it at the Society for the Advancement of Chicanos and Native Americans in Science conference, they also organized a panel to advise undergraduate students on graduate school, professional pathways, and the status of underrepresented minorities in the marine sciences. (0333444: Knowlton, University of California San Diego Scripps Institute)

☐ A trainee developed and implemented a college senior-level course in environmental engineer-ing on decentralized and onsite wastewater management and reuse. In this class, students learned how to determine appropri-ate onsite and decentralized wastewater treatment and solu-tions based on the principles of engineering technologies, ecology, and policy and management. (0333408: Kalonji, University of Washington)

NSF Investment Priority: Prepare a Diverse, Globally Engaged STEM Workforce

One-hundred fourteen (114) of the 136 IGERTs reporting in 2006-2007 identified outreach to nonprofit organizations, government agencies, international entities, and universities, colleges, and 2-year colleges. Table 8 summarizes the variety of the interactions.

Table 8: IGERT Outreach Activities to Nonprofit Organizations, Government Agencies, International Entities and Universities

# Involving nonprofit organizations	# Involving government agencies	# Involving international entities	# Involving other universities, 4- and 2-year colleges
121 activities 41 grants (36.0%)	54 activities 20 grants (17.5%)	69 activities 22 grants (19.3%)	164 activities 57 grants (50.0%)

Examples of IGERT outreach to nonprofit organizations, government agencies, international entities, and other institutions of higher learning include:

Nonprofit organizations

☐ A trainee studying public policy and nuclear threats presented information about U.S. relations with Saudi Arabia and Egypt in a talk, "Rethinking Risks and Reas-sessing Rewards: U.S.-Saudi and U.S.-Egyptian Relations" to the RAND Corporation, a nonprofit think tank in Washington, D.C., that

conducts research on global and complex problems, thus influencing public knowledge about key political issues. (0221706: Shirk, University of California San Diego)

Government agencies

☐ Thirty-five (35) prisoners at the San Quentin State Penitentiary were able to earn college credit toward AA degrees by the efforts of an IGERT trainee who taught an introduction to American government course. The focus of this IGERT is involvement in social systems, evaluation of the effects, costs and benefits of policies, and implementing legislation consistent with original legislative intent. The trainee also presented results from her research on correctional officers and the perceptions of safety on the job to the correctional officers of the penitentiary. (0504642: Raphael, University of California Berkeley)

International entities

☐ Research conducted by an IGERT on the social and ecological impacts of climate change at high latitudes and the implications for ecological management and society was shared at the University of Northern British Columbia in the form of a seminar. (0114423: Chapin, University of Alaska Fairbanks)

☐ IGERT faculty and trainees have given invited lectures in China at Yunnan University, the Beijing Institute of Zoology, the Kunming Institute of Zoology, and the Southwest Forestry University at Yunnan, on topics including how to study the impact of peasant policy, ecology of digestion, the impact of plant phenolics on mammalian and avian herbivores and park and people relationships, promoting international education through IGERT interdisciplinary training. (0549369: Posner, University of Wisconsin Madison)

Other universities, 4- and 2-year colleges

☐ Educating undergraduates about the integration of mathematics and biology and enticing them into STEM fields in graduate school is the purpose of a series of lectures given at Bowdoin College, the Claremont Colleges, Ohio State University, Rockhurst University in Missouri, the University of Utah, Augsburg College, the University of Hawaii, and the University of Alberta by IGERT faculty and trainees. Topics ranged from a mathematician's look at blood clotting, the mathematics of heart attacks, the mathematical estimation of whole-forest uptake and release of carbon, and the opportunities for interdisciplinary research in mathematical biology. (0217424: Keener, University of Utah)

☐ A summit focusing on changes in the Columbia River Basin was organized and presented at the Columbia Gorge Community College for community college students and the public. The topics of natural processes and human influences on the Columbia river and its estuary, climate change, global warming and the Pacific Northwest and invasive species and native plant restoration are an outgrowth of the interdisciplinary IGERT's research on the Earth's subsurface biosphere and the links to Earth's physical and chemical environments and processes. (0114427: Myrold, Oregon State University)

NSF Investment Priority: Engage and Inform the Public in Science and Engineering Through Informal Education and Outreach

IGERTs reported 688 instances of outreach to groups summarized in Table 9. Activities ranged from radio and television interviews to websites, lectures, field trips, and museum presentations and exhibits. Trainees and faculty alike participated.

Table 9: IGERT Outreach Efforts Through Informal Education

Outreach Group	General public or community	Organizations	Government	International	Universities or colleges	Industry
Number of outreach instances	275	121	54	69	164	5
Number of IGERTs reporting the outreach	64	41	20	22	57	2

Examples of IGERT outreach efforts through informal education include:

☐ A two week trip to El Salvador by trainees for Engineers Without Borders resulted in a drinking water assessment of the area as part of an IGERT's research of the Earth's subsurface biosphere that could solve major environmental, agricultural, and industrial problems. Engineers Without Borders is a nonprofit humanitarian organization that partners with developing communities worldwide to improve quality of life through the implementation of environmentally and economically sustainable engineering projects, while developing internationally responsible engineering students. Using data provided by IGERT trainees, the organization is implementing a sustainable water delivery system in El Salvador. (0114427: Myrold, Oregon State University)

☐ The California Department of Fish and Game and U.S. Wildlife Service used the services of an IGERT trainee to inform their policies on the management and protection of amphibians and reptiles. (0114432: Strauss, University of California Davis)

☐ The Science Museum of Minnesota featured an IGERT trainee on its website that gave the public an opportunity to question a scientist about nanotechnology. The trainee is a mechanical engineering student and his description of his work, "he studies tiny, tiny dots," and explanation of how nanotechnology is being used in an attempt to detect cancer was of great interest to the public. http://dev.smm.org/buzz/museum/ask/arefe (0114372: Kortshagen, University of Minnesota Twin Cities)

☐ A film about the tree of life and the interrelatedness of all living things is being produced by the Peabody Museum of Yale University and will feature video interviews of IGERT researchers who are studying the interdisciplinary theme of computational phylogenetics and applications to biology. (0114387: Hillis, University of Texas Austin)

☐ "Why meat rots" is the topic of a story on *The Why Files*, a website designed to explain the science behind the news and make science accessible to all. The story is based on the research publications of IGERT trainees that explain how microbes use chemistry to compete with larger organisms. http://whyfiles.org/shorties/219bacterial_stink/

This research is also shared on *YubaNet*, a website that delivers daily news to the Sierra. http://www.yubanet.com/cgi-bin/artman/exec/view.cgi/21/44957 (0114400: Hay, Georgia Tech Research Corporation-GIT)

☐ In an IGERT program that seeks to effectively and ethically contribute to solving critical problems facing tropical working forests, an IGERT trainee led an ecological research methods workshop for biology and agroforestry undergraduate students at the Universidad de la Amazonia Pando in Bolivia. (0221599: Zarin, University of Florida)

☐ An IGERT trainee and Iraq veteran founded the *Open Prosthetics Project*, a nonprofit website that applies the ethical and intellectual property foundation of open source software to the task of building better artificial limbs in the search for a realistic and fully functional prosthetic. The IGERT research concerning biologically inspired materials is the foundation for this project. The story was featured in *Wired*, a magazine that reports how technology affects culture, the economy, and politics. http://www.wired.com/gadgets/mods/news/2006/09/71797. (0221632: Clark, Duke University)
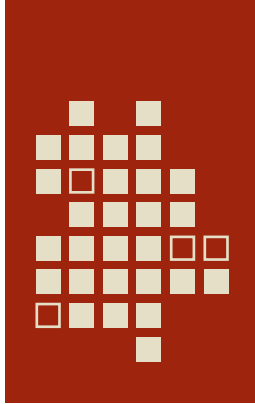
CHAPTER 4

Trainees—Broadening Participation

The current science and engineering workforce is aging. To meet the continuing, strong demand it will be important that every American has the opportunity to achieve in mathematics and science. Women, minorities and persons with disabilities remain underrepresented in STEM professions while they are an increasing percentage of the U.S. overall workforce.

— NSF Strategic Plan

IGERT trainees represent a cross-section of America. As a program, IGERT takes very seriously the solicitation mandate to facilitate diversity in student participation and preparation, and to contribute to a world-class, broadly inclusive, and globally engaged science and engineering workforce. Mandated by Congress that trainees must be citizens or permanent residents, a critical part of review criteria for all IGERT proposals is the recruiting and retention plan, not only for the best students, but explicitly for women and underrepresented minorities.

One-thousand five-hundred nineteen (1,519) trainees were funded in 2006-2007 by the IGERT program overall across 136 active IGERTs. One-hundred fifty-four (154) trainees received their doctoral degrees through the 136 active IGERTs reporting in 2006-2007 (84 male; 65 female; 5 gender not reported; 9 underrepresented minorities). Eighteen (18) trainees chose to complete a master's degree (10 male; 6 female; 2 gender not reported; 7 underrepresented minorities).[3] Table 10 shows the alignment of IGERT trainees with research themes of importance to the nation, as outlined in Chapter 1.[4]

When asked to compare the quality of their IGERT trainees to their other graduate students, 94.85% of IGERT PIs rated IGERT trainees as far superior or somewhat better than their usual graduate students.

1. Far superior to our usual graduate students: 27.94%

2. Somewhat better than our usual graduate students: 66.91%

3. About the same as our usual graduate students: 4.41%

4. Somewhat less promising or less successful than our usual graduate students: 0%

5. Much less promising or less successful than our usual students: 0%

The remainder of this chapter will detail trainee demographic data with comparison to national data, in so far as is possible. This will include comparisons by discipline which is the most meaningful comparison to illustrate the way in which IGERT is raising the bar for broadening participation by diverse groups in STEM.

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[3] Reporting of gender and minority status is completely voluntary by trainees. Compliance rates vary for gender, race, and ethnicity.

[4] NOTE: Themes are overlapping and one IGERT may cover multiple theme areas. Hence trainees may be multicounted.

Table 10: Alignment of Trainees With Research Themes

TOPICS	# Trainees
Sustainability: ecology and the environment	488
Computational science and engineering	476
Human and social dimensions of new knowledge and technology	488
Nanoscience: engineering and technology	287
Energy: alternate and renewable resources and conservation	44
Materials science and engineering	305
Bioinformatics	96
Civil infrastructure monitoring and improvement	12
Entrepreneurialism	224
Neuroscience: biology and psychology	71
Climate change: impacts and factors	76
Biological evolution and development	92
Diverse device development	292
Sensing, signals, imaging and signal processing	176

IGERT Trainees: Comparisons to National Data Sets

Accurate comparison of IGERT trainee data to national data requires defining a national data set that most closely resembles IGERT trainee demographics. Specifically, IGERT trainees are all declared doctoral students, as no master's students are currently supported, and must be U.S. citizens or permanent residents. Data for comparison selected to be as close as possible to these demographic requirements for IGERT are from the NSF compilation of 2005 doctorates awarded by sex, citizenship status, and major field of study of the recipients.[5] While not identical to the IGERT trainee data for 2006-2007 in that IGERT trainees are still in a graduate program, this is the only data set which allows for control of the variables of doctoral program, citizenship status, gender, and race/ethnicity – major variables for meaningful comparisons to IGERT trainees.

To enable more detailed comparison of IGERT data with national data, both overall statistics by gender, race, and ethnicity as well as a detailed breakdown analysis of IGERT trainees by major field of study using the fields described in the national data set have been compiled. To determine field of study for individual trainees, the department in which the trainee is currently enrolled was used as a proxy for the analysis.

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[5] NSF SRS data Table 3: Doctorates awarded, by sex, citizenship status, and major field of study of recipients: 1996-2005.

Table 11 illustrates that for race/ ethnicity IGERTs are ahead of national data in meeting the goal of the Solicitation in facilitating diversity in student participation and preparation, and to contribute to a world-class, broadly inclusive, and globally engaged science and engineering workforce. As the table shows, for gender, IGERTs are similar to national data overall.

Table 11: IGERT Trainees Compared with National NSF Data for Gender, Race and Ethnicity

	# IGERT Trainees	IGERT %	Science Resources Statistics (SRS) National Data %
Gender			
Female	635	41.8	44.5
Male	876	57.7	55.4
Not reported	8	.5	——
Race/Ethnicity [6]			
American Indian/Alaskan Native	18	1.2	0.4
Black or African American	82	5.4	4.4
Hispanic or Latino	91	5.9	5.0
Asian, Native Hawaiian & other Pacific Islanders	129	8.5	No comparable SRS data
White	1,101	72.5	76.6
Not reported	151	9.9	——

When analyzed by race and ethnicity, *IGERT trainee data exceeds or is equal to national data for 70% of all fields* (Table 12).[7] For females, when broken down by field, IGERT is *engaging more females into nontraditional fields for the gender. IGERTs exceeded national data for females in 80% of* *fields and were slightly lower in 20% of fields* (Table 13). Table 14 summarizes the alignment of male IGERT trainees by field with national data. Tables 13 and 14 also convey information about the concentration of fields for the 2006-2007 IGERT grants.

For IGERT trainees there was a 9.9% non-report rate for race/ethnicity and a 1.3% non-report rate for field of study. Among females there was a 1.1% non-report rate for field of study. Among males, the field non-report rate was 1.4%.

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[6] Count will exceed the total of 1,519 trainees due to trainee double race/ethnicity.

[7] IGERT trainee data exceeds national data 50% of the time for all fields.

Table 12: IGERT Trainees' Race and Ethnicity by Field of Study Compared to National Data[8]

Field of Study	% American Indian, Alaskan Native IGERT*	% American Indian, Alaskan Native SRS	% Black or African American IGERT*	% Black or African American SRS	% Hispanic or Latino IGERT*	% Hispanic or Latino SRS	% White IGERT*	% White SRS	% Asian, Native Hawaiian & other Pacific Islanders IGERT***
Aeronautic & Astronautics Engineering	0.00	0.07	0.00	0.01	0.00	0.04	**7.00**	0.46	0.00
Astronomy	**0.00**	0.00	0.00	0.01	0.00	0.02	0.00	0.62	0.00
Biological Sciences	**0.46**	0.07	0.86	0.99	**1.51**	1.42	16.13	20.83	1.80
Chemical Engineering	**0.07**	0.00	**0.26**	0.09	**0.79**	0.13	**5.00**	1.48	0.60
Chemistry	**0.20**	0.01	**1.12**	0.26	**0.46**	0.34	**7.50**	5.97	0.70
Civil Engineering	**0.00**	0.00	0.00	0.06	**0.13**	0.07	**2.37**	1.19	0.13
Computer Sciences	0.00	0.006	0.00	0.09	**0.13**	0.07	**3.69**	2.04	0.80
Earth, Atmospheric and Ocean Science	**0.07**	0.02	**0.26**	0.04	**0.39**	0.11	**3.75**	2.396	0.20
Electrical Engineering	0.00	0.02	**0.20**	0.193	**0.13**	0.09	**2.76**	2.196	0.30
Industrial Engineering	**0.00**	0.00	**0.07**	0.05	0.00	0.01	**0.66**	0.31	0.13
Mathematics	**0.00**	0.00	0.07	0.14	**0.13**	0.10	2.30	2.58	0.06
Mechanical Engineering	**0.07**	0.02	**0.39**	0.07	**0.20**	0.08	**1.71**	1.48	0.40
Other Engineering**	**0.07**	0.006	**0.86**	0.12	**0.66**	0.069	**7.97**	1.97	1.60
Physics	0.00	0.01	**0.46**	0.07	**0.26**	0.099	**4.67**	2.78	0.50
Psychology	0.07	0.09	0.07	1.02	0.53	1.17	1.84	14.27	0.13
Social Sciences	**0.13**	0.12	0.79	1.05	0.66	0.93	11.45	12.08	1.10

* NOTE: In Tables 12, 13 and 14, bolded numbers indicate that IGERT trainee data exceeds or is equal to national data. The data for all IGERT columns are calculated using the following formula: (# IGERT Trainees with that field as their home department for their doctoral degree and associating themselves with the specific demographic group / Total # of IGERT trainees in 2006-2007 reporting period) X100. There are 1519 IGERT Trainees in this reporting period. The data for all SRS columns are calculated using the following formula: (# doctorates earned in that field by the demographic group indicated as reported for 2005 / Total # of doctorates earned in S&E) X100. (Footnote 8 below). This data set was selected for its closest alignment with IGERT trainees – all of whom must be US citizens or permanent residents and are pursuing doctoral degrees. The data show 16024 earned doctorates across all fields for 2005. We acknowledge the lack of perfect alignment of this data set and that of IGERT trainees.

** NOTE: The "other engineering" category is comprised primarily of biomedical engineering.

*** NOTE: There are no comparable SRS data for this category.

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[8] NSF SRS data Table 5: Doctorates awarded to U.S. citizens or permanent residents, by race/ethnicity and major field of study or recipients: 1996-2005.

Table 13: Comparison by Field of Female Trainees With National Data

Field of Study	% of Females – IGERT*	% Females – National Data
Astronomy	**0.2**	0.2
Biological Sciences	11.7	13.5
Engineering:		
Chemical Engineering	**2.2**	0.5
Electrical Engineering	**0.8**	0.5
Civil Engineering	**1.4**	0.5
Industrial Engineering	**0.3**	0.1
Mechanical Engineering	**0.7**	0.3
Other Engineering	**4.7**	0.7
Chemistry	**5.2**	2.8
Computer Sciences	**1.0**	0.7
Earth, Atmospheric, Ocean	**2.9**	1.0
Mathematics	**1.0**	0.9
Physics	**1.3**	0.5
Psychology	1.1	12.4
Social Sciences	7.0	8.1

Table 14: Comparison by Field of Male Trainees With National Data

Field of Study	% of Males – IGERT*	% Males – National Data
Astronomy	0.0	0.5
Biological Sciences	9.7	13.9
Engineering:		
Aeronautic & Astronautics Engineering	0.3	0.5
Chemical Engineering	**4.2**	1.5
Electrical Engineering	**3.1**	3.0
Civil Engineering	**1.2**	1.1
Industrial Engineering	**0.6**	0.37
Mechanical Engineering	**2.5**	1.7
Other Engineering	**7.3**	2.1
Chemistry	**5.8**	4.8
Computer Sciences	**10.7**	2.3
Earth, Atmospheric, Ocean	**2.4**	1.7
Mathematics	1.7	2.4
Physics	**4.8**	3.0
Psychology	1.4	5.6
Social Sciences	**8.2**	7.8

* NOTE: In Tables 12, 13 and 14, bolded numbers indicate that IGERT trainee data exceeds or is equal to national data.
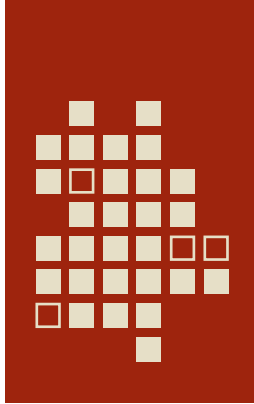
CHAPTER 5

IGERT Looking Ahead FY 2008-2009

To inspire and transform....

NSF advances scientific discovery by supporting transformational and distinctive new capabilities — those innovations in research and education that move discovery well beyond the boundaries of current knowledge.

— NSF Strategic Plan

The IGERT program looks forward to continuing at the vanguard of inspiring new and innovative models of transformative interdisciplinary graduate training. Now in its tenth year, the IGERT program continues to innovate not only through grants but also through the management of the program.

As a guidepost for the program, IGERT has adopted three strategies to ensure that the Solicitation and NSF goals that frame the program are addressed:

1. Synthesize and use the knowledge developed by the IGERT program as the basis for articulating and communicating the value of interdisciplinary education, research, and training to IGERT stakeholders, in general.

2. Facilitate and enable learning and communication among the IGERT community to both improve the IGERT program and each IGERT project.

3. Ensure alignment of NSF support, structure, roles, and responsibilities.

Beginning in 2006-2007 for FY 2008-2009 these strategies have led to the following initiatives:

- **Cyber-enabling collaboration and information exchange** among IGERTs and between IGERTs and the NSF and the general public.

  □ An upgraded **Solicitation** for FY 2009 which addresses

    > **IGERT Resource Center**— a web-based community for IGERT

> Information dissemination and sharing among IGERTs using tools such as webinars and Access Grid.

□ Determining the extent to which IGERTs are aligned with the goals of the new Cyber-enabled Discovery and Innovation initiative (CDI) and overall cyberinfrastructure (CI) initiative.[9]

IGERT Vision

Leading the nation in enabling transformative interdisciplinary graduate education through knowledge, ideas, practice, evaluation, and dissemination.

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[9] Umesh Thakkar – IGERT Linkages to CDI and CI; DGE Internal Report, 2007.

- **Improvements in project monitoring and post award oversight**:

  □ Enhanced methods of annual report collection which foster sharing accomplishments in research, education, and by trainees as well as sharing and disseminating learning and data from all IGERTs. This annual report is an example of the use of these data.

  □ Upgraded final reporting and dissemination to the entire NSF.

- **Evaluation** of IGERT with respect to trainee achievements after graduation with a longitudinal study being undertaken in 2008.

- Proposing a series of **workshops to determine the impacts** of integrative interdisciplinary research and education training on institutions, faculty, graduate students, the economy and workforce, and scientific disciplines.

  □ The first of these, an Institutional Workshop, is scheduled to be held after the IGERT PIs' meeting in May 2008.

- **Continually improving processes** for engagement of and involvement with NSF as a whole through interactions of the IGERT Coordinating Committee and other means, as appropriate.

□ Developing a compendium of IGERT **best practices** for sharing across NSF.

The remainder of this chapter gives illustrations of specific initiatives using the IGERT Resource Center and determining the alignment of IGERT with CDI and CI as examples. IGERT encourages readers to view our FY 2009 Solicitation at http://nsf.gov/publications/pub_summ.jsp?ods_key=nsf08540.

IGERT Linkages: Cyber-enabled Discovery and Innovation Initiative (CDI) and Overall Cyberinfrastructure (CI) Initiative

Since the start of the IGERT program, there have been 195 IGERT project awards. In response to the 2006 IGERT program solicitation,[10] 443 preliminary proposals were submitted. Of these, 100 preliminary proposals were invited to submit full proposals. IGERT received 98 full proposal submissions. After the full proposal panel reviews, there were 20 IGERT awards for FY 2007.

As part of the DGE programs' review, these recent IGERT awards and their connections to the emerging NSF Cyberinfrastructure vision were assessed.[11] Connections between these 20 IGERT awards for FY2007 and the new Cyber-enabled Discovery and Innovation research initiative[12] were also defined.

Utilizing Ucinet,[13] the social network analysis software,[14] various relationships among these projects and NSF directorates in addition to the possible connections to CI and CDI are illustrated.[15] Figure 1 shows how these projects connect to NSF directorates. Each numbered circle represents a unique IGERT project funded in 2007. The lines illustrate the connection among directorates and IGERT projects. For instance, 12 IGERT projects have possible connections to the Mathematical and Physical Sciences (MPS) Directorate (represented as a green node). Nine of these are new projects (represented as blue nodes), while 3 are renewal projects (represented as red nodes). In this cohort, every IGERT project has connections to at least 2 NSF directorates.

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[10] http://www.nsf.gov/pubs/2006/nsf06525/nsf06525.htm

[11] http://www.nsf.gov/pubs/2007/nsf0728/index.jsp

[12] http://www.nsf.gov/about/budget/fy2008/pdf/39_fy2008.pdf
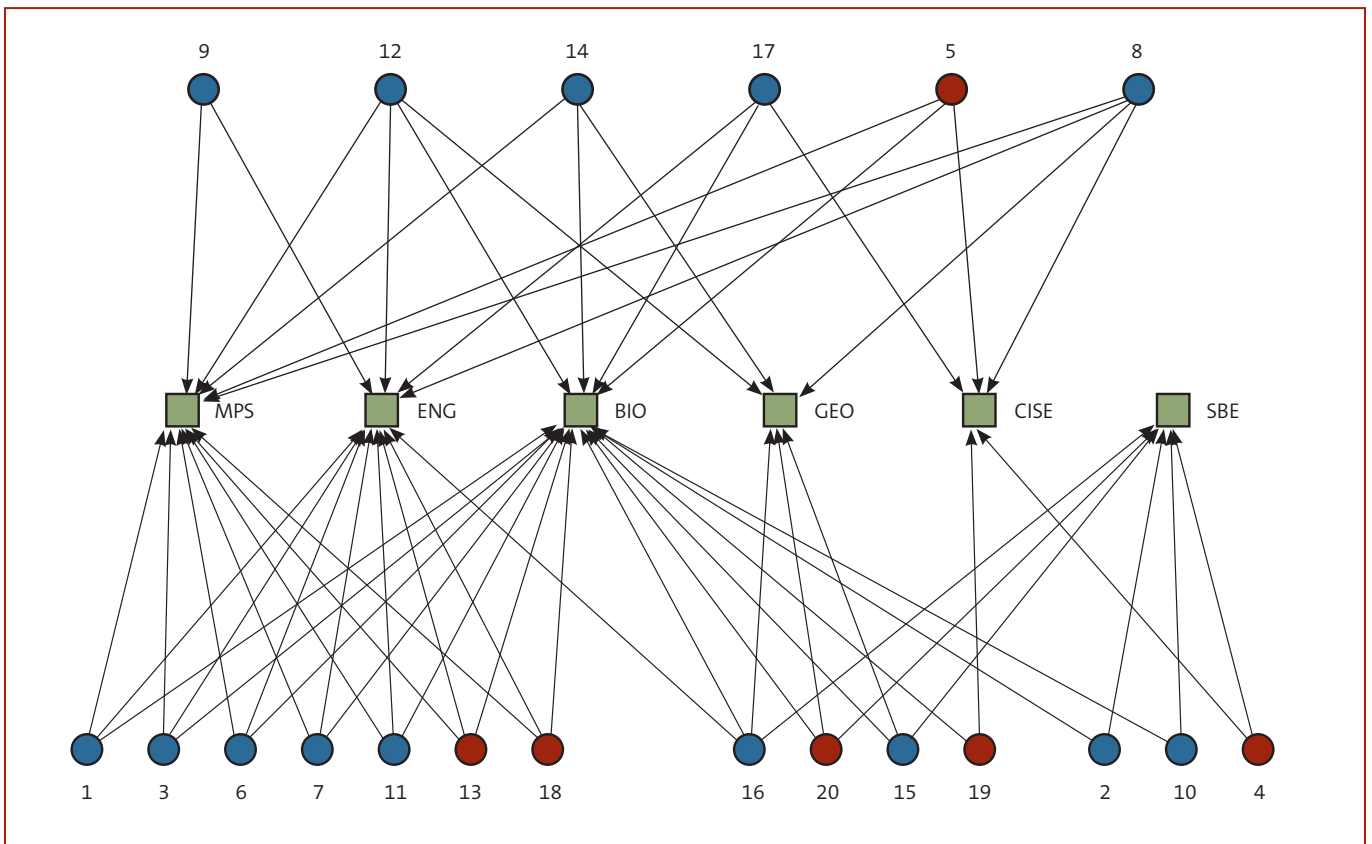
[13] Borgatti, S.P., Everett, M.G., and Freeman, L.C. (2002). *Ucinet for Windows: Software for Social Network Analysis*. Harvard, MA: Analytic Technologies.

[14] http://www.analytictech.com/downloaduc6.htm

[15] In this document, the distances among nodes have no particular interpretation.

**Figure 1: IGERT projects and NSF directorates**

Eight projects have possible connections to cyberinfrastructure aspects (see Figure 2). For instance, one project (identified as # 8) has connections to 3 CI aspects. This project is also connected to 4 NSF directorates. For the remaining 12 projects, it was not clear at this time how these projects have connections to cyberinfrastructure. As indicated in Figure 3, all 20 projects have possible connections to the CDI. The project (identified as #8) has connections to 3 CDI themes.

Figure 2: IGERT projects and cyberinfrastructure aspects
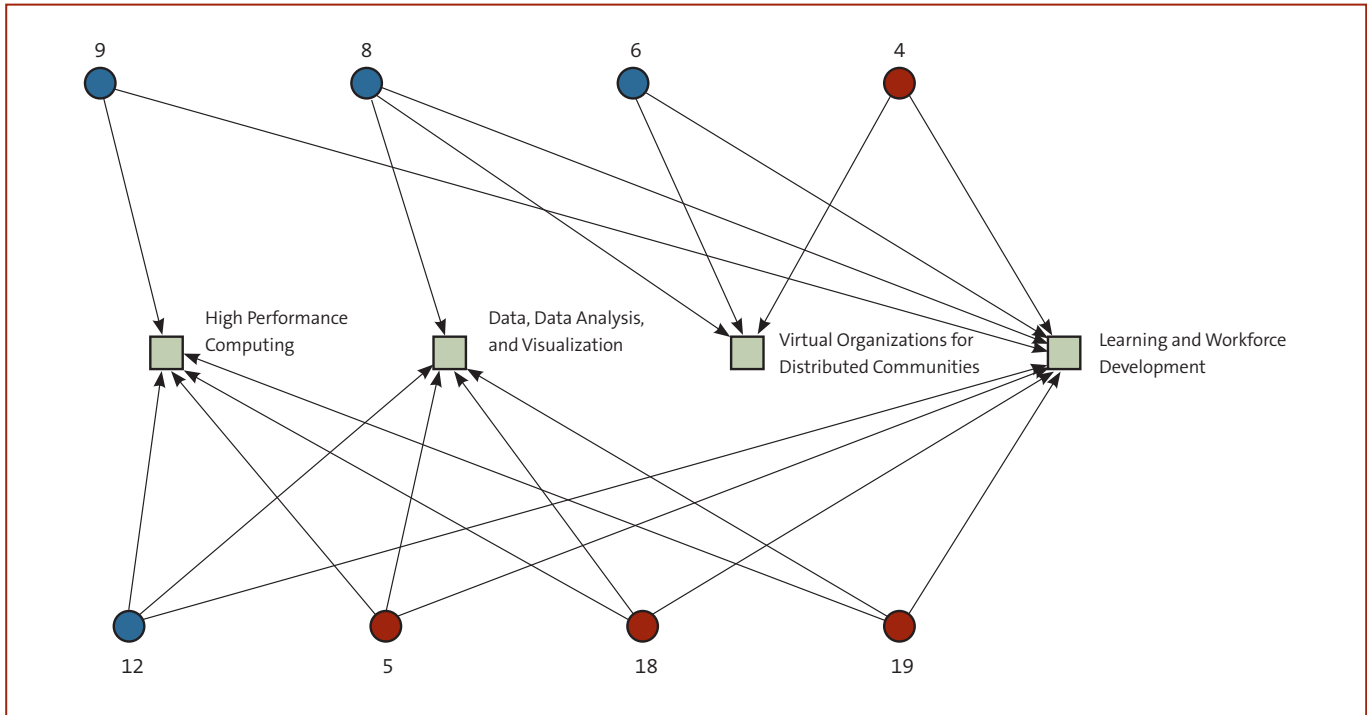
Figure 3: IGERT projects and cyber-enabled discovery and innovation themes
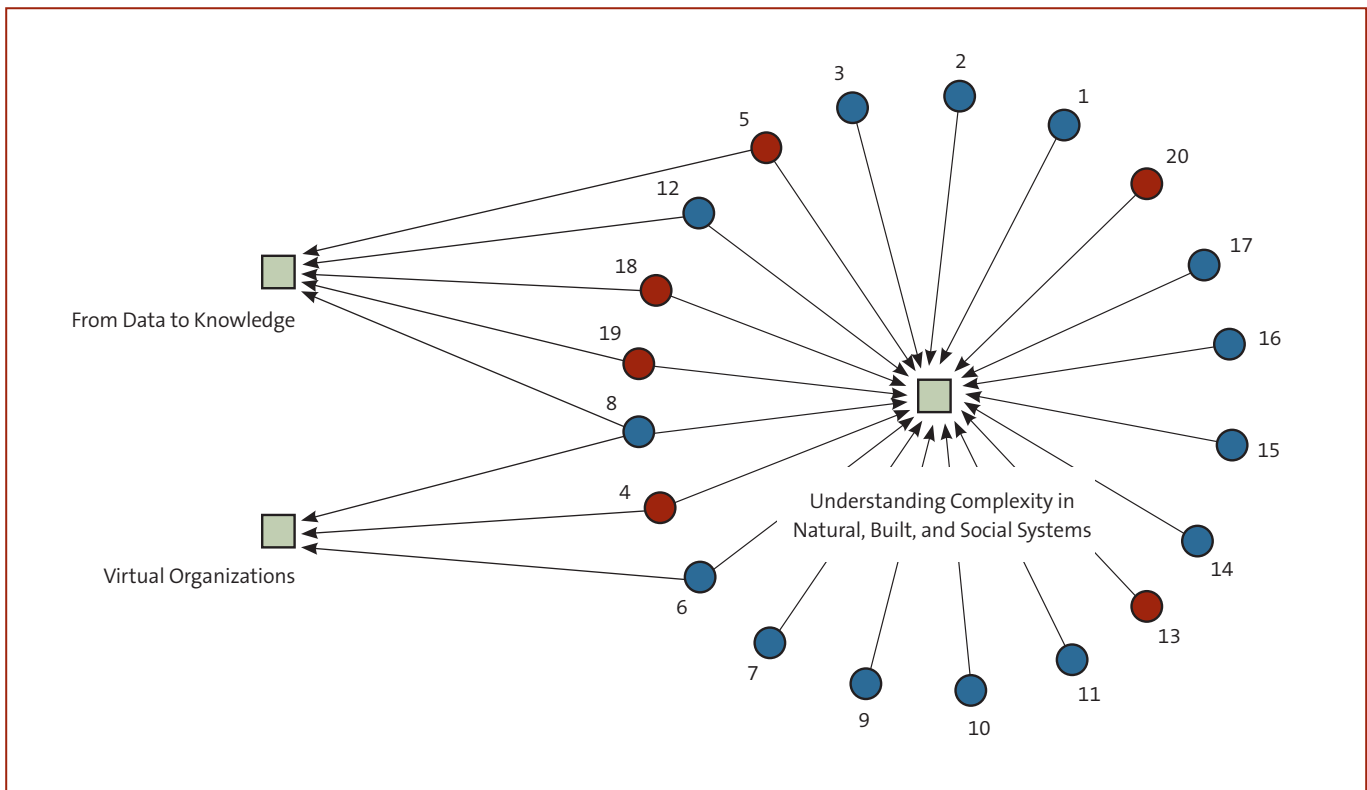
Resource Center

With the release of the FY 2009 grant solicitation, institutions being awarded IGERT grants will be committed to creating a supportive environment for cyber-enabled audio and video collaboration. The suggested tool to provide this form of communication is the Access Grid. Using an ensemble of open source videoconferencing resources developed by Argonne National Labs, Access Grid supports group-to-group (or individual) communication through high-speed networking over the web (Internet-2). It provides high quality audio and video interaction along with capabilities for sharing and inter-acting with files and applications.

Utilizing Access Grid, program officers, faculty staff, IGERT trainees, and other members within the IGERT community will be able to participate in collaborative discussions with their colleagues from across the country in the comfort of their offices and home institutions. It is anticipated that NSF program officers will have the opportunity to conduct "virtual" site visits. Tremendous savings in both time and money will be realized once the IGERT Access Grid is utilized to its full capacity.

Another new project underway to further facilitate collaboration within the IGERT community is an IGERT Resource Center. It is envisioned that the resource center will provide information and tools through a web-based, electronic venue for sharing, interaction, communication, and information dissemination. Content items under consideration for incorporation include IGERT bibliographies, facilitated and ad hoc forums, curriculum repository, IGERT library, educational outreach portals, wikis, online virtual workshops, and workshop archives. The resource center is anticipated to be the hub of the IGERT cyber-community and a center for anyone seeking additional information related to the IGERT program.

The intent of the report is to give an overview snapshot of the IGERT program through the lens of the compiled annual reports of the individual IGERTs. Therefore, the methodology for the report is simple summation and reporting. No evaluation of the results or implications from these results have been drawn, as this is a descriptive report only.
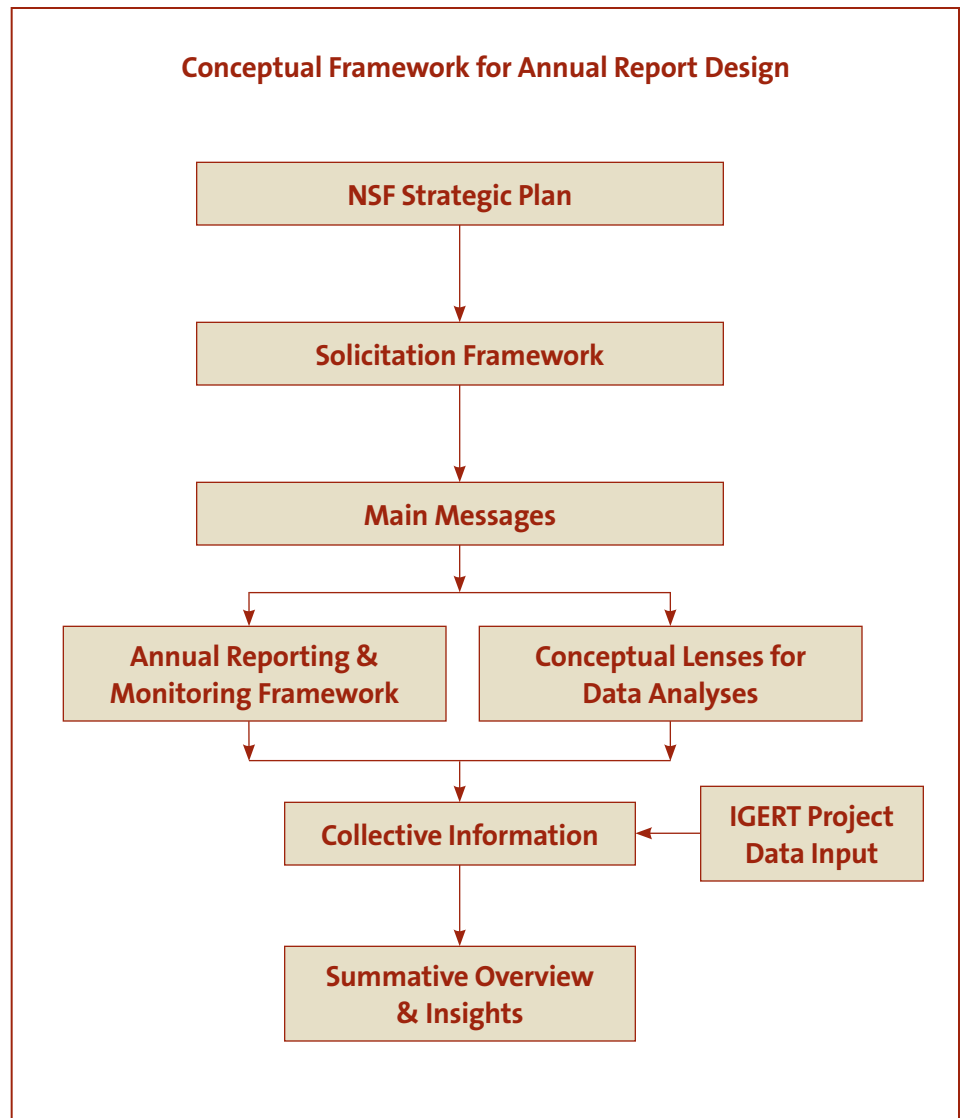
The report summarizes the input of the 136 individual IGERT project annual reports submitted for the 2006-2007 collection period as submitted on the web-based reporting system for IGERT. Topics for summation were derived from the content of the reports which was itself developed using the IGERT Solicitation and NSF Strategic Plan as the guidelines. In 2008, the annual report for IGERT will again be upgraded allowing for a 2007-2008 report with greater richness.

The conceptual framework for this report illustrates the linkages among the NSF Strategic Plan, IGERT Solicitation, the IGERT annual project reports, and this descriptive report.

IGERT 2006-2007 Annual Report Concept: Demonstrate the value of the IGERT program by providing IGERT stakeholders with an annual summary and overview of the progress, achievements, practices, and statistics of active IGERT projects.

Conceptual Framework for Annual Report Design

NSF Strategic Plan

↓

Solicitation Framework

↓

Main Messages

↓

Annual Reporting & Monitoring Framework | Conceptual Lenses for Data Analyses

↓

Collective Information ← IGERT Project Data Input

↓

Summative Overview & Insights

Front Cover (left to right):
Reference stand 10 of the H.J. Andrews Long-term Ecological Research (LTER) site provides long-term monitoring of forest conditions, allowing researchers to reconstruct past disturbances and understand how these past events have shaped the character of today's forest. (0333257: Jones, Oregon State University)

Credit: Al Levno, USDA Forest Service, Pacific Northwest Research Station

Marin Conservation Corps Director Deborah Schoenbaum and youth volunteers assisted with an eradication effort coordinated by an IGERT trainee. (0114432: Strauss, University of California Davis)

Credit: Ann Dickinson

"Flower Bouquet," a 3-D nanostructure grown by controlled nucleation of silicon carbide nanowires on Gallium catalyst particles. As the growth proceeds, individual nanowires 'knit' together to form 3-D structures.

Credit: Ghim Wei Ho and Prof. Mark Welland, Nanostructure Center, University of Cambridge

Elephants in Chobe National Park, Botswana. (0504422, Brown, University of Florida)

Credit: MT Brown

Brian D. Iverson, a mechanical engineering doctoral student at Purdue University, holds up a disk containing several "micro-pump" cooling devices, which are small enough to fit on a computer chip. The tiny pumps circulate coolant through channels etched into the chip.

Credit: David Umberger, Purdue University News Service

Page 9: Pampas grass (*Cordateria jubata*), an invasive species that naturalizes throughout California and still is readily available in the retail trade. (0114432: Strauss, University of California Davis)

Credit: Mandy Tu

Page 10 (top): A student tests the biofeedback for rehabilitation system being developed by the experiential media IGERT at ASU. (0504647: Rikakis, Arizona State University)

Credit: Tim Trumble

Page 10 (bottom): IGERT trainees and associates developing and testing the SMALLab environ-ment. (0504647: Rikakis, Arizona State University)

Credit: Ken Howie

Page 11: Professor Stephen Walsh with GPS device in the Galapagos Islands. (0333193: Entwisle, University of North Carolina Chapel Hill)

Credit: Amy McCleary

Page 12: Laser mediated heat shocks. Transgenic wing tissue from Bicyclus Anynana butterflies showing EGFP expressing cells due to a line heat shock. Higher magnifica-tion of EGFP expressing cells. Wildtype wing tissue after line heat shock. Complex grid pattern of EGFP expression. Complex butterfly pattern of EGFP expression as a result of laser heat shock. Scale bar = 100 μm in all panels. (0114330: Cartwright, State University of New York Buffalo)

Credit: D. M. Ramos, F. Kamal, E. A. Wimmer, A. N. Cartwright, and A. Monteiro, "Temporal and spatial control of transgene expression using laser induction of the hsp70 promoter," BMC Developmental Biology, vol. 6, Nov 2006

Page 14: Atmospheric science laboratory classroom with meteorological instruments and data acquisition systems for hands –on learning. (0221688: Mehta, Texas Tech University)

Credit: Courtesy of Wind Science and Engineering Research Center, Texas Tech University - Kishor C. Mehta

Page 15 (top right): Molecular Dynamics of Monoamine Oxidase B: A Monotopic Memberane Protein: Images generated by William Allen using VMD (unpublished). This image shows a close up of the tail sections under investigation. (0333378: Duncan, Virginia Polytechnic Institute and State University)

Credit: William Allen

Page 15 (middle left): Tailored Macromolecules for DNA Complexation and Cell Transfection. (0333378: Duncan, Virginia Polytechnic Institute and State University)

Credit: John Layman

Page 16: Elephants in Chobe National Park, Botswana. (0504422: Brown, University of Florida)

Credit: MT Brown

Page 18 (top): As part of the up-and-coming $1.4 Billion Spallation Neutron Source at Oak Ridge National Laboratory, Oak Ridge, Tennessee, the VULCAN engineering diffractometer is being developed. VULCAN's design allows for multiple detector-bank converage with in-situ tension and compression capabilities. This setup is currently unavailable among neutron engineering diffractometers in the world. (09987548: Liaw, University of Tennessee Knoxville)

Credit: Adapted from Materials Science and Engineering A, 437, 126-133, 2006

Page 18 (bottom): Electrode Array Smaller Than a Penny. (0549352: Touretzky, Carnegie Mellon University)

Credit: Ryan Kely, Matthew Smith, and Tai Sing Lee, Center for the Neural Basis of Cognition, Carnegie Mellon University

Page 19 (middle column): MAO-B dimer embedded into a lipid bilayer. (0333378: Duncan, Virginia Polytechnic Institute and State University)

Credit: William Allen

Page 20: Students and WISE personnel documenting damage caused by Hurricane Katrina. (0221688: Mehta, Texas Tech University)

Credit: Courtesy of Wind Science and Engineering Research Center, Texas Tech University' - Kishor C. Mehta

Page 21: Reference stand 10 of the H.J. Andrews Long-term Ecological Research (LTER) site provides long-term monitoring of forest conditions, allowing researchers to reconstruct past disturbances and understand how these past events have shaped the character of today's forest. (0333257: Jones, Oregon State University)

Credit: Al Levno, USDA Forest Service, Pacific Northwest Research Station

Page 22: Mini-Z THz spectrometer. (0333314: Wang, Rensselaer Polytechnic Institute)

Credit: Brian Schulkin

Page 23: Apparent slip velocity as a function of bulk shear rate (flow intensity) for a polydimethylsiloxane (PDMS) melt of molecular weight 970,000 in contact with a surface with tethered PDMS chains with a molecular weight of 96,000. The experimental data are by Durliat et al. [Europhys. Lett., 38, 383-388 (1997)]. (0221589: Denn, City University of New York City College)

Credit: The figure is from a paper "A stochastic chain simulation of wall slip in entangled polymer melts" by Fang Xu, Morton M. Denn, and Jay D. Schieber, to appear in the Journal of Rheology in May, 2006. NSF has permission to use the figure.

Page 26: TTUWindfluvana: Students and instructors visiting wind farm near Lubbock, Texas. (0221688: Mehta, Texas Tech University)

Credit: Courtesy of Wind Science and Engineering Research Center, Texas Tech University - Kishor C. Mehta

Page 29 (left column): University of Maine Sensor Science, Engineering and Informatics Project. (0504494: Beard-Tisdale, University of Maine)

Credit: UMaine SSEI E. Roy

Page 29 (right column): Marin Conservation Corps Director Deborah Schoenbaum and youth volunteers assisted with an eradication effort coordinated by an IGERT trainee. (0114432: Strauss, University of California Davis)

Credit: Ann Dickinson

Page 30: Cathy McNally and Mr. Doto Masamba, a Saadani Park Ranger, recording river edge habitat condition during an ecological reconnaissance of the Wami River in Tanzania. (0504103: August, University of Rhode Island)

Credit: Baraka Kalanghe

Page 30 (bottom left): IGERT SKINS trainee Andrea Wesser served as a student volunteer during the 2006 Micro/Nano Summer Rootics Camp at the University of South Florida. (0221681: Bhansali, University of South Florida)

Credit: Praveen Sekhar

Page 31: 2007-2008 MCTP Fellows, October 3, 2007. Top row (L-R) Matthew Allen, Jeffrey Wright, Li-Min (Raymond) Chen; 2nd row (L-R) Zachary O'Brien, Gregory Kuzmanich, Steven Jonas; 3rd row (L-R) Iris Rauda, Danny King; 4th row (L-R) Michael Kahn, Cortnie Vogelsberg, Dyanara Parra, Laura Saldarriaga-Lopez, Sabah Bux; 5th row (L-R) Emil Song, Wyatt Nelson. Not pictured are Augustin Hong, Alexander Tucker-Schwartz. (0114443: Garrell, University of California Los Angeles

Credit: UCLA Materials Creation Training Program

Page 35: The invasive Japanese mud snail, *Batillaria attramentaria*, may be small, but can have a tremendous impact on ecosystems of San Francisco Bay. (0114432: Strauss, University of California Davis)

Credit: Ann Dickinson

Page 36: MILES IGERT trainee, Abby Turpyn Peairs, presenting her research in the national conference. (Duncan: Virginia Polytechnic and State University)

Credit: Abby T. Peairs

Page 37: A student tests the biofeedback for rehabilitation system being developed by the experiential media IGERT at ASU. (0504647: Rikakis, Arizona State University)

Credit: Tim Trumble

Page 39: IGERT Trainee Scot Waye presented a 30-minute discussion of common indoor air pollutants and their sources to kick off a trainee organized public workshop on Indoor Air Quality. (Corsi: University of Texas Austin)

Credit: Ralph Barrera, Austin-American Statesman

Back Cover (left to right): Detecting Biological Samples Lab-on-a-chip being tested under fluorescence microscope for detection of biological samples.

Credit: Melvin Khoo, Sam Lu and Change Liu, University of Illinois at Urbana-Champaign

Shubha Chakravarty conducting fieldwork in Kenyya. (0333418: Stiglitz, Affiliation)

Credit: Shubha Chakravarty

Kristen Baker views some of her study subjects, tobacco hornworms

Credit: Rick Fatica; Image courtesy Perspectives Magazine