

Integrative Graduate Education and Research Traineeship (IGERT) IGERT for Nano

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IGERT-Synopsis

- The Integrative Graduate Education and Research Traineeship (IGERT) program has been developed to meet the challenges of educating **U.S. Ph.D. scientists and engineers with interdisciplinary backgrounds, deep knowledge in chosen disciplines, and technical, professional, and personal skills.**
- The program is intended to establish **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.**
- Building upon the IGERT platform, the purpose of this IGERT solicitation is to support new models in graduate education in which students are engaged in an environment that supports innovation to **learn through hands-on experience how their own research may contribute in new ways to benefit society and to learn the processes for the successful implementation of such contributions.**



Grand Challenges-NAE Report

Engineering's Grand Challenges

X

WHAT
DO YOU
THINK?

Voting Results:



Make solar energy economical

Votes: 12779



Provide energy from fusion

Votes: 7512



Provide access to clean water

Votes: 7213



Reverse-engineer the brain

Votes: 4640



Advance personalized learning

Votes: 3670



Restore and improve urban infrastructure

Votes: 3483



Engineer the tools of scientific discovery

Votes: 3396



Develop carbon sequestration methods

Votes: 2743



Engineer better medicines

Votes: 2563



Prevent nuclear terror

Votes: 2309



Advance health informatics

Votes: 2283



Secure cyberspace

Votes: 2240



Enhance virtual reality

Votes: 2106



Manage the nitrogen cycle

Votes: 1864



Addressing Grand Challenges

- Grand Challenges are inherently
 - Interdisciplinary, complex
 - Involves not just science and engineering, but also policy, government, and geopolitics
- Plans to tackle grand challenges should include:
 - Systematic training for future scientists and engineers to take on these challenges
 - Strategic support for research
 - Building an innovation ecosystem



NAE Summit Series on Grand Challenges

“change the way we educate our students in order to better prepare them for the challenges ahead”

- Engineering education must be coupled to policy/business/law and must be student-focused.
- Enhance student interest in engineering, science, and technology entrepreneurship.
- <http://summit-grand-challenges.pratt.duke.edu/>



IGERT Program Goals

- Interdisciplinary research experience
- Deep knowledge in chosen disciplines
- Innovative educational plan
- Technical, professional, and personal skills
- Develop career skills desired by both academic and non-academic employers
- Intended to catalyze sustainable institutional change in graduate education for the training of future scientific research workforce
- Broadening participation



IGERT

Dissemination of
innovative
education

Communicate
research to non-
science audience

Outreach

Recruiting

Broadening participation

Retention

Global awareness

Innovative, integrated education plan

Innovation skills

Professional skills

Ethics and RCR

Teamwork

Cutting-edge, interdisciplinary, STEM research
(Addressing Societal problems and Grand Challenges)



Some Features of IGERT

- Encourages experiments that may result in changes of existing models for Graduate Education
- Emphasizes a type of Counter-Cultural Research and Education Experiment
- Provides a substantial increase in resources for enhanced impact
- Provides a framework wherein institutions, through PIs, can propose programs with enough flexibility to accommodate students' desire to design an education plan to match his/her career goals
- Provides a means for program performance assessment



Educational Features of IGERT Projects

- **New curricula**

- Interdisciplinary courses, laboratories, seminars, often team-taught, cohort learning environment
- Student-taught interdisciplinary courses

- **New integrative experiences**

- “boot camps,” workshops, retreats
- Team projects and teamwork exercises
- Student-lead and -organized meetings
- Laboratory rotations; co-advising

- **Internships**

- Industry, national laboratory, research institute
- International



Integrative Graduate Education and Research Traineeship (IGERT)

- Awards to institutions (\$3-3.2M/5 years); senior PIs
- Recent competitions have 154 full-proposals, ~18 awards (12%)
- Since 1997:
 - 278 awards
 - 122 different lead institutions
 - 43 states, DC, and Puerto Rico
 - ~25 trainees/award, typically supported 2 years/each
 - ~6,500 PhD students have been supported



Some IGERT Interdisciplinary Themes

- Smart sensors and integrated devices
- Biosphere-atmosphere research
- Molecularly designed materials
- Assistive technology
- Sequential decision-making
- Urban ecology
- Astrobiology
- Alternate Energy
- Nanotechnology



Nanoscale Science in IGERT

- 32 active awards including 5 renewals directly focused on Nanoscale Science involving
 - Biology
 - Devices and machines
 - Electronics
 - Fabrication
 - Laminates
 - Materials; Biomaterials
 - Medical
 - Particles
 - Pharmaceutical
 - Photonics
 - Probes



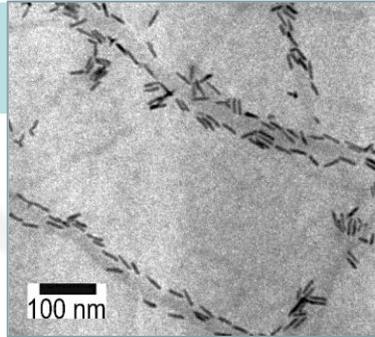
Nanoscale IGERTs Driving Innovation

-Nanowires for photovoltaics (UMass)

- Designer crystals for sustainable electronics (Cornell)

-Nanoscale optics (Rice)

- Role of mineral nanoparticles as transporters of toxic trace metals (Virginia Tech)

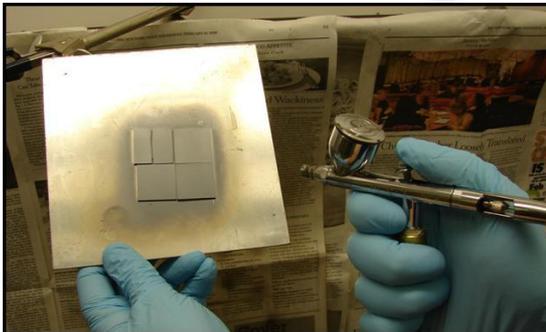


Pharmaceutical processes
Public Policy
Energy
Nanomedicine
High-performance batteries
Nanotoxicology
High temperature sensing electronics

Advance State-of-the-art through cutting edge Interdisciplinary science

Translational research

Applications



-Biocompatible sensors to track blood sodium levels (Northeastern)

- Low-cost nanocrystal-based photovoltaics (UT-Austin)

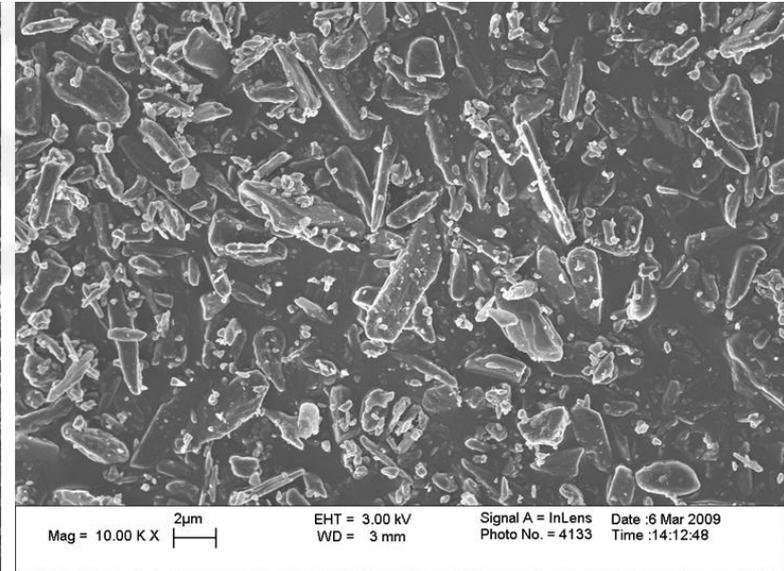
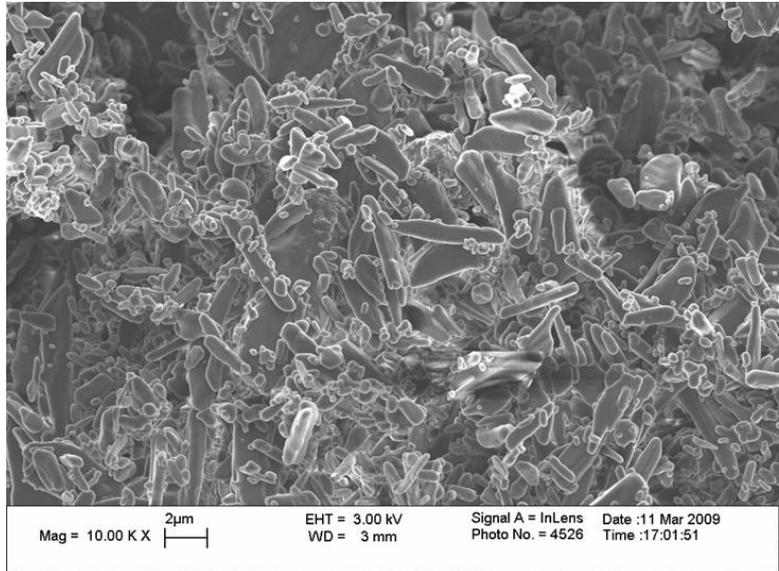
- Nanoparticles for drug delivery (UMass, New Mexico)

- Scalable highly conductive transparent films (UCLA)



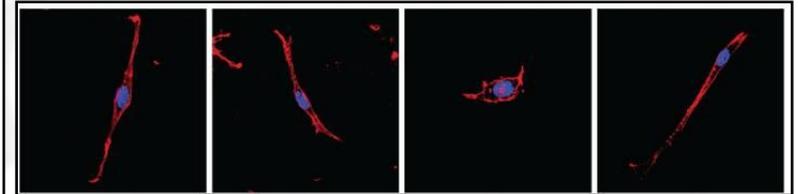
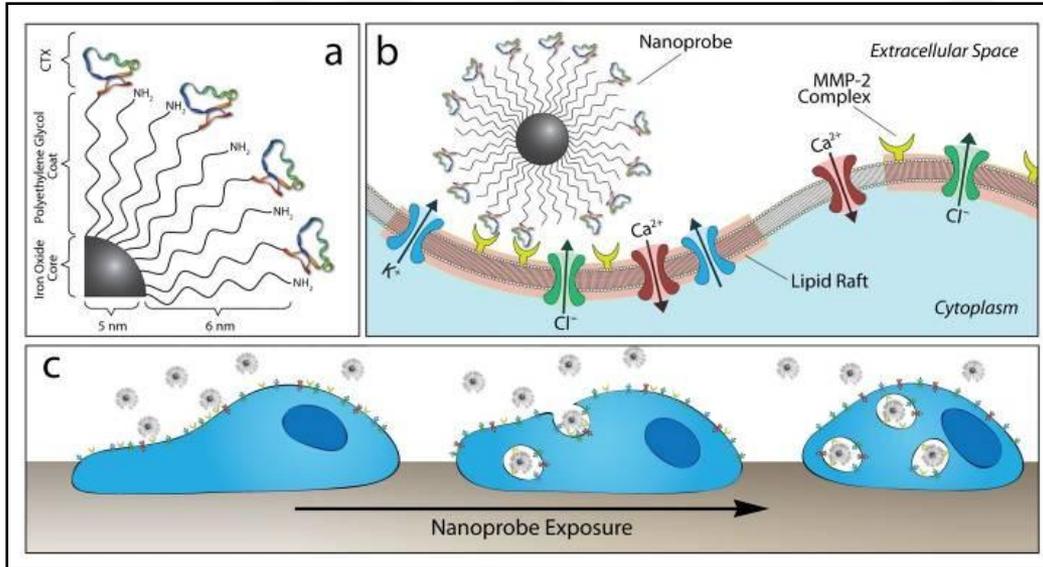
NanoPharmaceutical Engineering and Science

Fernando Muzzio, PI, Rutgers U



- SEM image on left is for the case of size reduction without nano-coating, which leads to excessive agglomeration and poor dispersion. SEM image on right is for the case of size reduction with nano-coating, which leads to reduced agglomeration and very good dispersion.

Scorpion Venom With Nanoparticles Halt Brain Cancer Spread

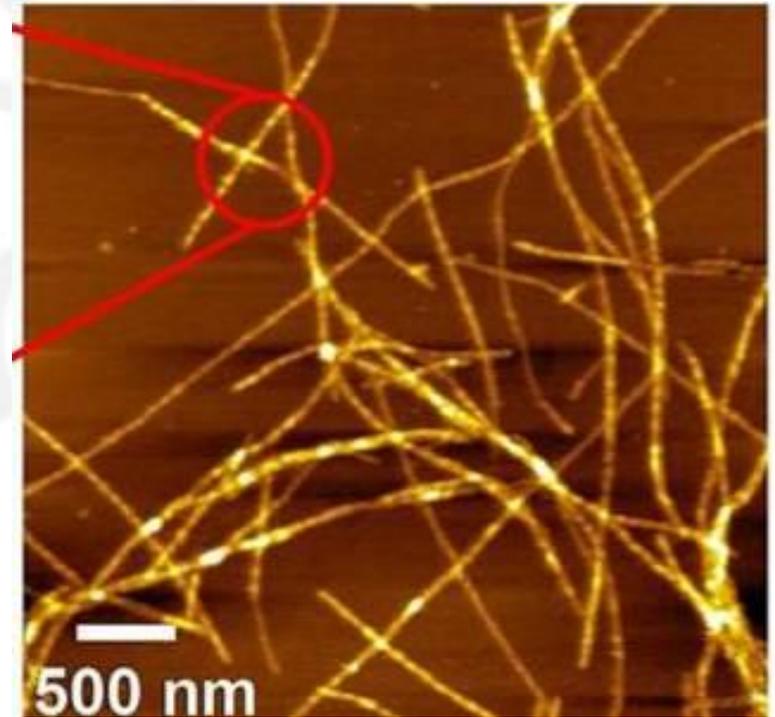


Each nanoparticle complex can simultaneously latch on to many MMP-2s (yellow), which are thought to help tumor cells migrate through the body.

Physical & Biomolecular Foundations for Designing Nanoprobes for Biology

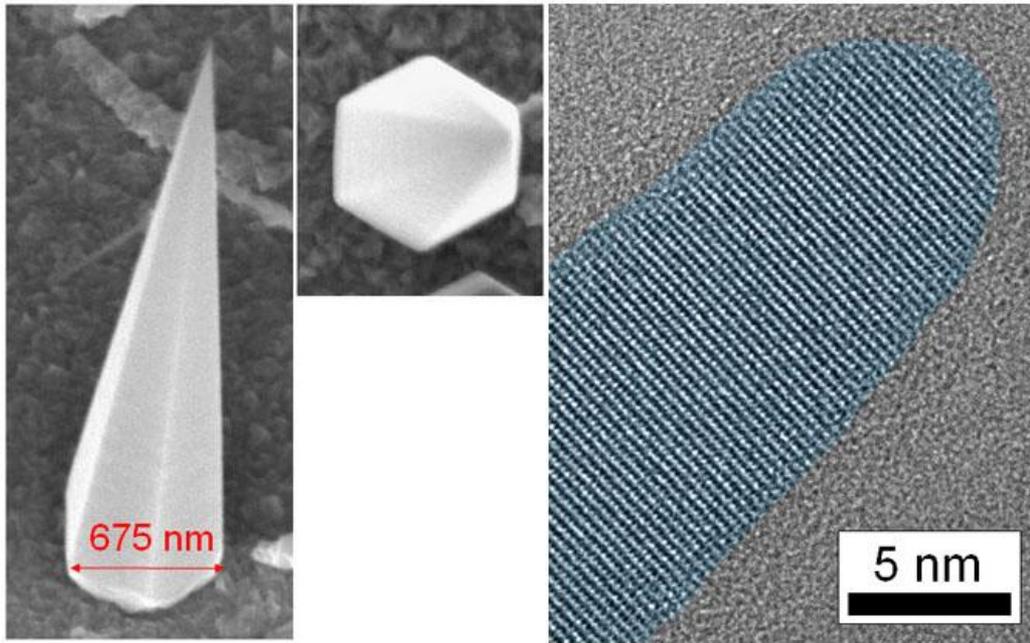
Konstantinos Konstantopoulos,
PI, Johns Hopkins U

- Nanowires from natural proteins which give them unique biological properties and allow for a link between electronic and biological systems.
- Long-term applications of these nanowires include tissue engineering and in-vivo imaging.



Photoluminescence in Nano-needles

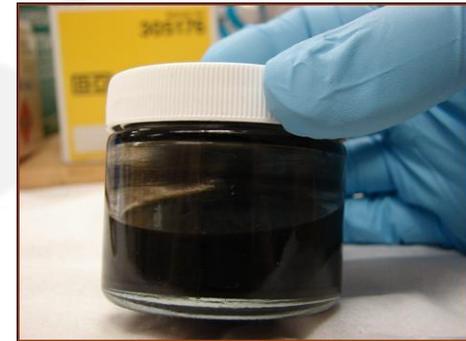
Constance Chang-Hasnain, PI,
UC Berkeley



- GaAs structures into the shape of narrow needles which, when optically pumped, emit light with high brightness.
- GaAs nano-structures with a shape of narrow needles having an angle of 6 degree down to tips of 2 to 5 nanometers across.
- Scanning electron micrographs (left and middle), high-resolution lattice image using transmission electron microscope (right).

Novel low-cost $\text{Cu}(\text{In}_{1-x}\text{Ga}_x)\text{Se}_2$ (CIGS) nanocrystal-based photovoltaics

Atomic and Molecular Imaging of Interfaces/Defects in Electronic, Spintronic, and Organic/Inorganic Materials
Chih-Kang Shih, PI, U Texas Austin



CIGS nanocrystal "ink" comprised of CIGS nanocrystals dispersed in tetrachloroethylene (TCE).



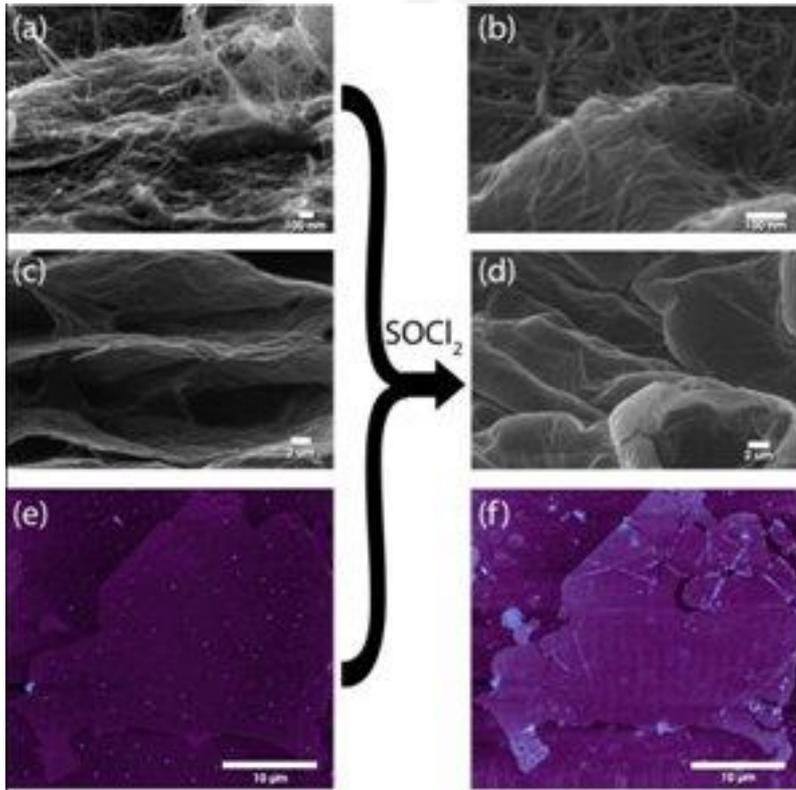
Image of CIGS nanocrystal-based photovoltaic device on a glass substrate



- CIGS-based solar cells
 - nearly 20% power conversion efficiency in the laboratory.
- Conventional fabrication of CIGS solar cells requires high vacuum deposition techniques
 - Too expensive
- CIGS nanocrystal "inks" that can be solution processed by a variety of techniques including drop-casting, dip-coating, spin-coating, airbrushing, and inkjet printing.

Highly conductive transparent films

Robin Garrell, PI, UCLA



Scanning electron micrographs (SEM) of graphene-CNTs nanocomposites, CCG and an atomic force micrograph (AFM) of a single CCG sheet.

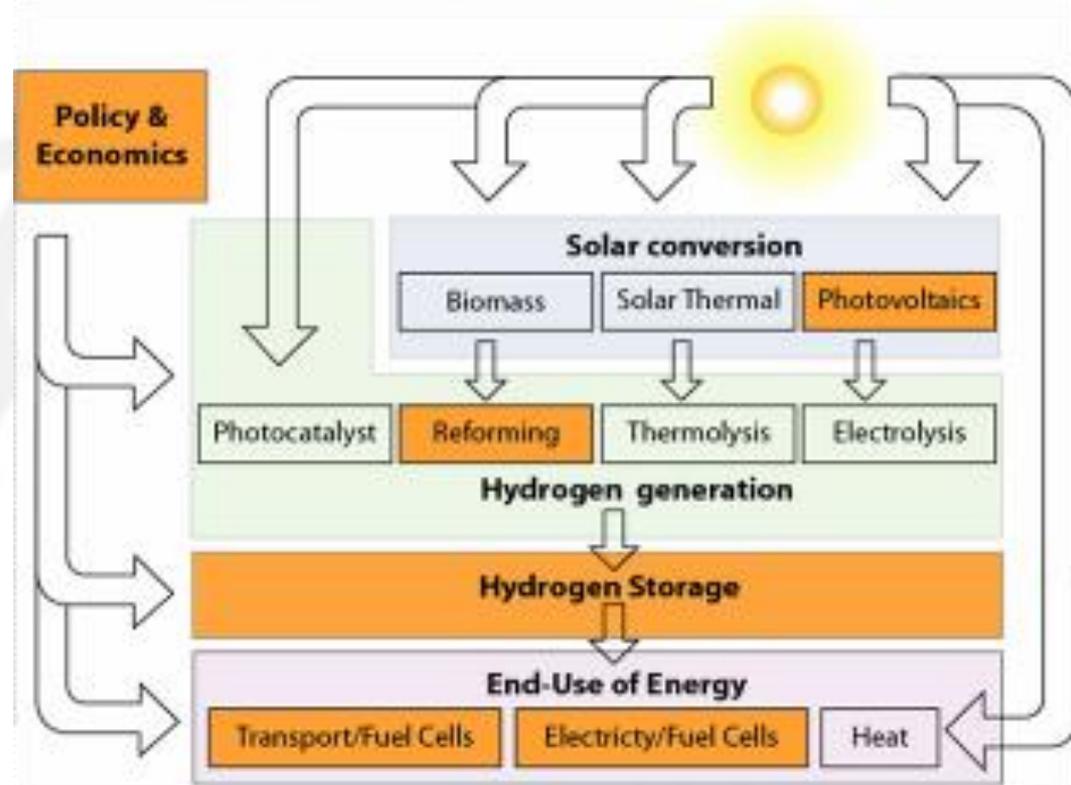
- The ability to deposit graphene and carbon nanotubes using solution-based methods dramatically lowers their processing costs. The conductivities from these materials have to be high in order for them to effectively replace indium tin oxide (ITO) as a transparent electrode in commercial devices.

- Thionyl chloride (SOCl_2), a widely used reagent in organic reactions, was found to effectively increase the electrical conductivity of solution-deposited chemically reduced graphene-carbon nanotubes by a factor of four.



Theme: Clean Energy and Engineering Processes

- Texas Tech University: Wind Science and Engineering



University of Delaware: Sustainable Energy from Solar Hydrogen



Universities with Nanoscale Science related IGERTs

- Carnegie Mellon University
- Cornell (3)
- Drexel University
- Georgia Tech
- Johns Hopkins University
- Norfolk State University
- Northeastern University
- Ohio State University
- Rutgers University (2)
- Rensselaer Polytech Inst.
- Tuskegee University
- UC-Berkeley
- University of Illinois-UC
- UC-Los Angeles (2)
- University of Oregon
- University of Massachusetts Amherst
- University of Missouri-Columbia
- University of New Mexico (2)
- University of Rochester
- University of South Dakota
- University of Texas Austin
- University of Utah
- University of Washington
- Vanderbilt University
- Virginia Tech
- William Marsh Rice University



What's New in IGERT?

- Support new models in graduate education in which students are engaged in an environment that supports **innovation** to learn through **hands-on** experience how their own research may contribute in new ways to benefit society and to **learn the processes for the successful implementation** of such contributions



New review criteria

- Interdisciplinary theme
- Theme that can support large number of PhDs
- Novel educational plan to cross disciplinary boundaries and foster an innovation environment
- Quality of innovation training aspects
- Plans for competitive Innovation Incentive Fund
- Broadening participation plans



Challenges for IGERT Trainees

- Coping with an interdisciplinary curriculum with disciplinary depth
- Having a critical mass and support group
- Role models
- Career counseling for landing on traditional faculty positions



Challenges for IGERT Faculty

- Departmental requirements
- Cultural differences among departments
- Administrative load on PI, faculty
- Release time or credit for faculty teaching
- Recognition for interdisciplinary teaching at (tenure or) promotion



Challenges for IGERT Institutions

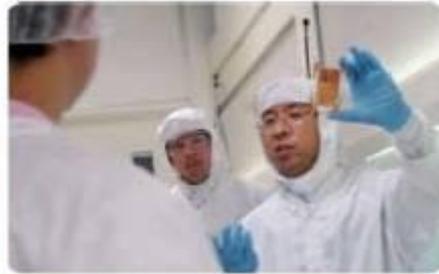
- Rewarding interdisciplinary graduate education by faculty
- Hiring new faculty outside traditional disciplines
- Rewarding interdisciplinary research by young faculty
- Overcoming resistance or inertia



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IGERT

Integrative Graduate
Education and
Research Traineeship



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About IGERT

IGERT is the National Science Foundation's flagship interdisciplinary training program, educating U.S. Ph.D. scientists and engineers by building on the foundations of their disciplinary knowledge with interdisciplinary training. [More details >>](#)

IGERT Resource Center

The IGERT Resource Center provides comprehensive information about IGERT and each of its actively funded projects. The Resource Center provides an e-community for current IGERT students and faculty to share resources, research, presentations, challenges and best practices. [More details >>](#)

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Science of the Future

