Perspective of NSF-MPS Program Directors on Educational Outreach

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The National Science Foundation Broader Impacts review criterion (often known as Criterion 2) has been subject to much discussion since first implemented by NSF in 1997. The broader impact of different proposals can vary widely, based on different factors such as the particular research activities proposed, the interests of the PI(s), the type of institution involved in the proposal, and the different opportunities available on the local area, to name just a few.

Conclusions

When it comes to broader impacts

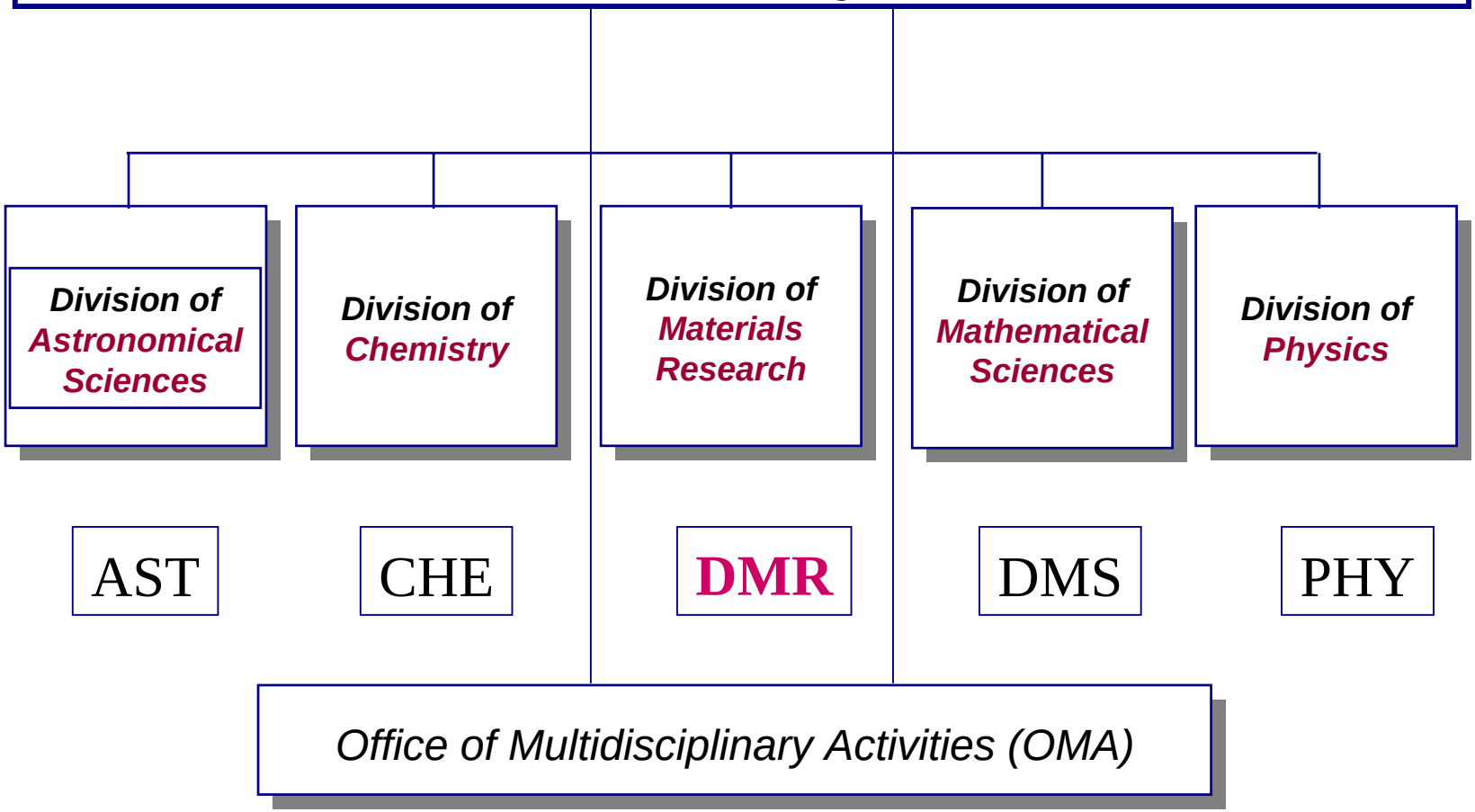
HIGHLIGHT

DO NOT HIDE

MENTOR

National Science Foundation

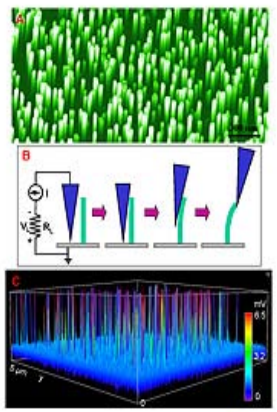
Directorate for Mathematical and Physical Sciences



Division of MATERIALS RESEARCH (DMR)

- **Inherently interdisciplinary** (***materials synthesis, characterization, novel phenomena, measurements and modeling …. devices***)
- ***Basic research*, often with potential applications**
- **Materials 'community' is very broad:**

  physicists, chemists, materials scientists, engineers, biologists, mathematicians, computer scientists, educators…



- **Education and Outreach activities are supported in all DMR programs**
  -- Centers play a major role
- **DMR is a major partner in NANO**

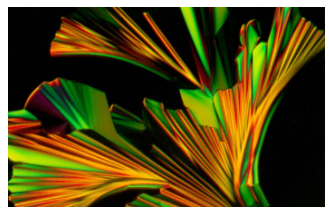
Materials Research (DMR)

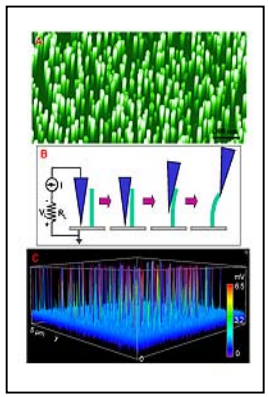
http://www.nsf.gov/div/index.jsp?div=DMR

Supports Research and Education activities related to materials – broad

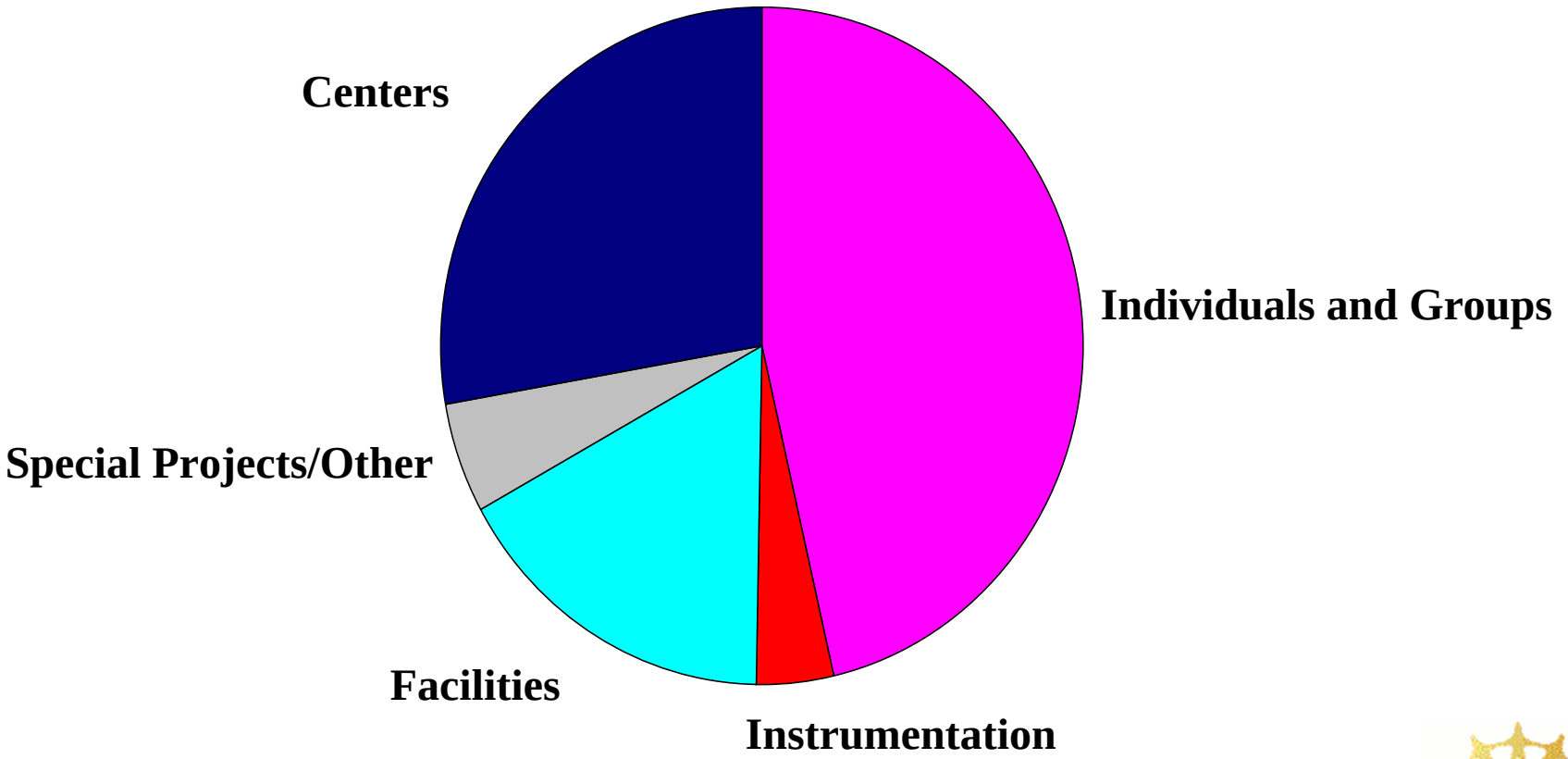
- Programs

- Biomaterials (BMAT)
- Ceramics (CER)
- Condensed Matter and Materials Theory (CMMT)
- Condensed Matter Physics (CMP)
- Electronic and Photonic Materials (EPM)
- Metallic Materials and Nanostructures (MMN)
- Polymers (POL)
- Solid State and Materials Chemistry (SSMC)
- Instrumentation for Materials Research (IMR)
- Materials Research Science and Engineering Centers (MRSEC)
- National Facilities
- Office of Special Programs (OSP: IMI, MWN, REU)

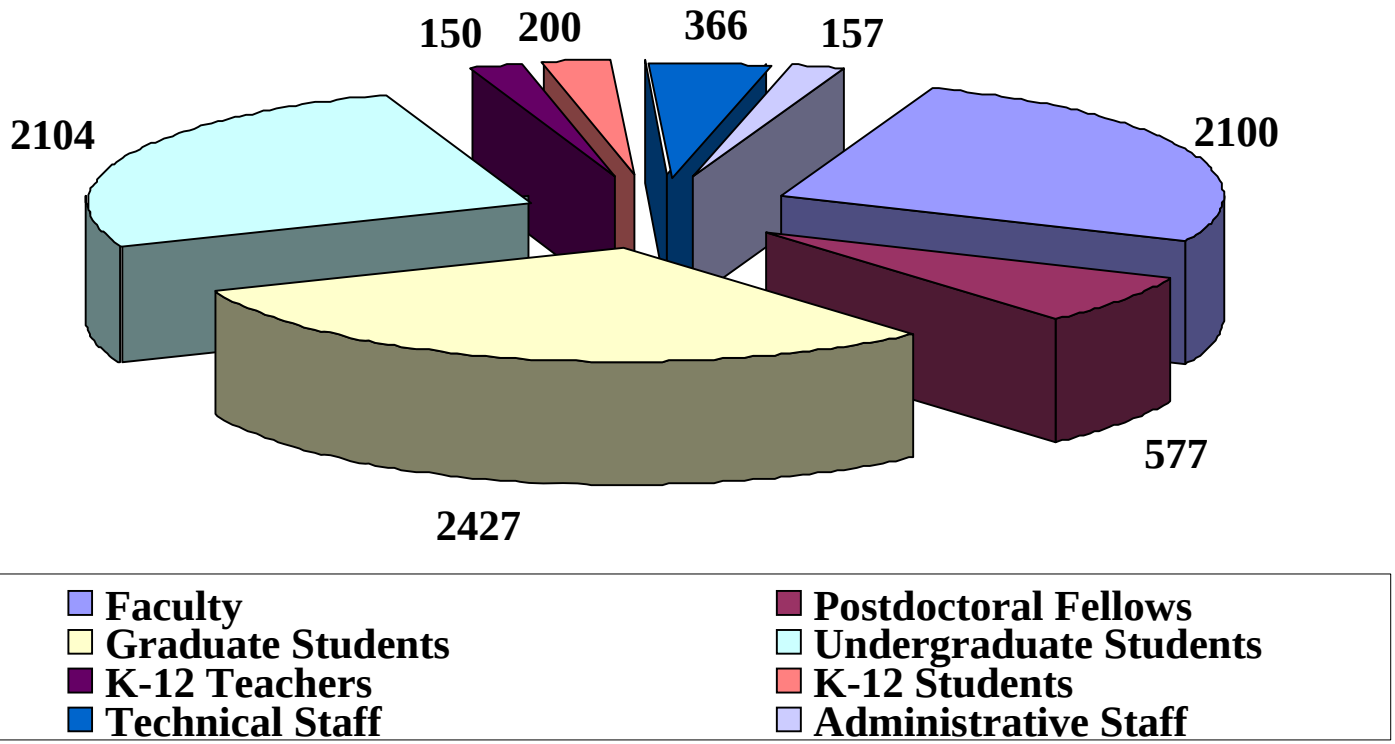




DMR Budget
$262.5 M in FY2008



Distribution of People Funded by DMR in Materials Research & Education



> 5,000 people used DMR-supported facilities in FY08

National Science Foundation

NSF Merit Review System

Proposal Evaluation Criteria

Proposals are evaluated based on two criteria:

- Intellectual Merit
- **Broader Impacts**

  Representative Activities

  http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf

FAQ: **When was the BI Criterion implemented?**

The merit review criteria were changed from four criteria (1981) to two criteria in 1997. The revised criteria retain the elements of the 1981 criteria, but add three areas:

1) Creativity and originality of concepts in a proposed activity (see Intellectual Merit criterion);
2) Specific intention to promote teaching, training, and learning in addition to advancing discovery and understanding; and
3) Broadening the participation of underrepresented groups.

The last two of these are incorporated into the **BI** criterion.

FAQ: why was the BI implemented?

Existing broader-impacts-related materials do not stress enough the correlation between broader impacts and the health of the STEM research enterprise e.g.:

Restructuring the criteria makes the broader impact and societal objectives more visible to the research communities and to Congress. We need to provide policy makers with arguments they can use to justify STEM research funding increases.

US demographics are changing. By 2050, Hispanics-Latinos are projected to comprise 24% of the total population and African-Americans will comprise 13%. Continuing the historical under-representation of members of these groups will further decrease the talent pool from which STEM disciplines and industries can draw. Critical to establish a qualified STEM workforce at all levels.

FAQ: why was the BI implemented?

- Involvement of STEM researchers with K-12 education: the U.S. superiority in STEM research has rested on the excellence of its higher education institutions; yet, the US lags behind other countries in STEM education at the K-12 level. The scientific research community must engage in significant partnerships with K-12 schools to provide high-quality STEM instruction. Few K-12 school systems have the expertise or experience to do this solely from internal resources; the STEM research community is unlikely to be pleased with outcomes not developed in collaboration with STEM researchers.
- A science-literate public is critical to increasing community support for science funding, and for making well-reasoned decisions about STEM issues such as low-level radioactive waste dumps, global climate change, stem-cell research, and a host of other topics that will be of increasing importance. Emphasizing the rationale for the broader-impacts criterion will emphasize its importance to the sustainability of STEM research in the US.

FAQ: How is BI used in proposal review

UNEVENLY

NSF has made several changes. In 2001, FastLane was modified to include two separate response boxes in which reviewers are required to address each criterion separately. Explicit instructions to reviewers request "detailed comments on the quality of this proposal with respect to each of the two NSF Merit Review Criteria". As of 10/02, NSF returns without review proposals that do not separately address both merit review criteria in the Project Summary. The broader impacts must be addressed in the Project Description and integrated in the narrative.

An internal NSF task force found that, from a sample of FY01 reviews, about 69% of reviews provided evaluative comments in response to the broader-impacts criterion. In FY02, 84% of reviews contained information in both the IM and BI text boxes, with this number rising to 90% in FY03. These numbers do not reflect the **quality** of information contained in the reviewer boxes or in the proposal.

FAQ: How is BI used in proposal review

A number of NSF Committee of Visitors (COV) reports find that, in addition to omitting entirely the BI criterion, some reviewers did not evaluate the BI based on the stated program guidelines and some reviewers identified BI on behalf of applicants who did not explicitly address this criterion in their proposals. They also found inconsistency between panel and mail reviews, with panel reviews providing more consistent evaluation of BI than mail reviews.

Inconsistencies are reported in the use of both merit criteria by program directors in justifying funding decisions.

FAQ

Why such problems? A few reasons have been identified.

The NAPA report (James Colvard, Mary Jane Bostrom, and Sandra Hale, *A Study of the National Science Foundation's Criteria for Project Selection,* (National Academy of Public Administration, Washington, DC, 2001) points out that the extensive list of activities that qualify for broader impacts suggests a check off list in which each item must be addressed.

COV reports also suggest that the breadth of possible activities makes it difficult for reviewers to consistently evaluate and compare the broader-impacts portions of proposals. “The metrics for performance in the broader-impacts area are 'much less well defined than those for intellectual merit”. Some criteria listed under 'intellectual merit' (such as qualifications of the applicant in executing the project and access to resources) apply equally to broader impacts.

BROADER IMPACTS

Advance discovery and understanding while promoting teaching, training, and learning

Broaden participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)

Enhance infrastructure for research and education
(facilities, instrumentation, networks, partnerships**)**

Dissemination of results

Benefits to society

DMR: Materials World Network International Materials Institutes

Value added by the collaboration (synergy)

Balance of intellectual efforts

Participation of students/junior researchers in Int. Activities

How do we get there?

Different programs targeted at various activities and individuals in the NSF Directorates and Divisions

Education and Outreach activities to engage students and teachers at all levels as well as the general public

Outreach efforts aimed at increasing science literacy of current and future citizens

Integration of Materials Research and Education

- **Individual investigators & groups (faculty, postdoc, grads, undergrads)**
- **CAREER (junior faculty; research and education integration)**
- **Research Experience for Undergraduates (REU) and Teachers (RET)**
- **Centers (MRSEC, STC) & user facilities (NHFML, CHESS ..)**
- **PREM (Diversity)**
- **International activities (MWN, IMI)**
- **K-12 Teacher preparation (**UTeach, MWM …)
- **Outreach to K-12 students, general public (science museum, Strange Matter Exhibit, Molecularium, …)**

BROADER IMPACTS

Advance discovery and understanding while promoting teaching, training, and learning

National Science Foundation

Advancing discovery and understanding while promoting teaching, training, and learning

*** It is not simply training graduate students and mentoring of postdoctoral fellows**

- Activities should go *beyond* normal teaching duties and faculty commitments*
- Should seek to engage, excite, recruit, and retain students at all levels by connecting research to education

Examples include:

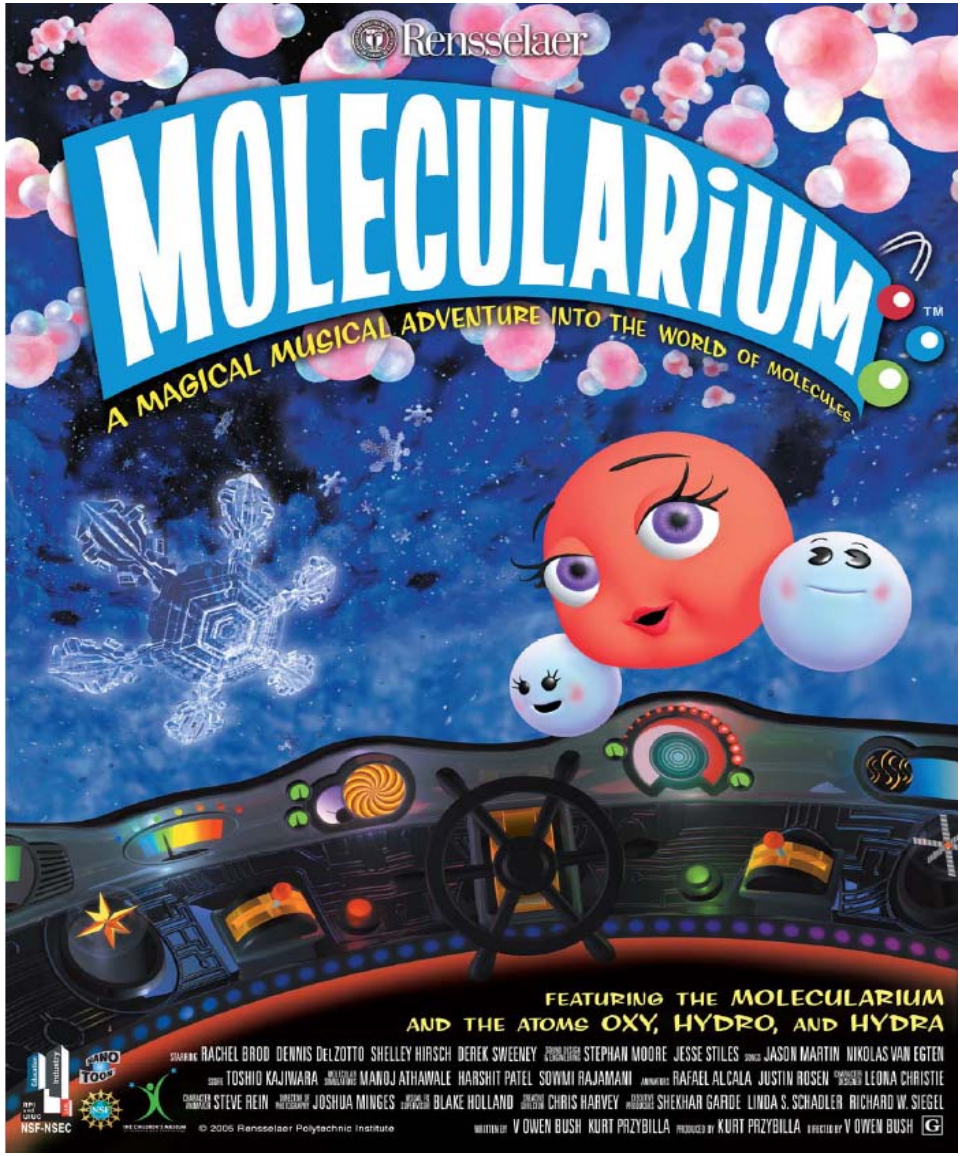
- ❖Creating opportunities to involve K-12 teachers, undergraduate and high school students in research
- ❖Participating in professional development of K-12 teachers to help them update the K-12 curriculum

NSF-MRSEC University of Maryland Highlight
Thinking Small: Nanoscale Informal Science Education (NISE) Activities

Alex Prasertchoung, Education Coordinator
Donna Hammer, MRSEC Associate Director and Education Director

- **The University of Maryland (UMD) MRSEC** joined the NISE Network in the nation-wide effort to bring nanoscience to communities across the country during the week of March 29 - April 6, 2008.
- **Service-based:** The Maryland MRSEC uses a service-based approach to carry out its education outreach mission. This approach allowed 12 faculty, post docs, and graduate students to get involved with NISE and present research-related information to students within the context of sharing nanoscience demonstrations. MRSEC developed inspiring nano presentations, brought additional materials that complimented the NISE kit demonstrations, and gave real application to research projects going on at UMD.
- **Exciting Week of Activities: 1:** MRSEC researchers visited Oxon Hill High School's **Science and Technology Program** where they effectively engaged 90 students, 6 teachers, and 2 external education consultants in nanoscience presentations and demonstrations.
- **2**: Nine Ernest Just Middle School science teachers participated in MRSEC's **Nanoscience Teacher Workshop**, during which they received one-on-one instruction, lessons, and supplies.
- **3:** MRSEC members visited Berwyn Heights Elementary School where they involved 55 5th and 6th graders and 4 teachers in **nanoscience activities**.
- **4**: During the MRSEC **Nanoscience Open House**, researchers shared a nanoscience presentation and activities with homeschool families.
- **5:** Sligo Creek Elementary School families learned about the nanoworld at **Family Science Night** from MRSEC researchers.

UMD MRSEC DMR0520471



"If only one idea had to be passed on to the next generation, it is the concept of Atoms and Molecules, and that everything is made of them" RICHARD P. FEYNMAN

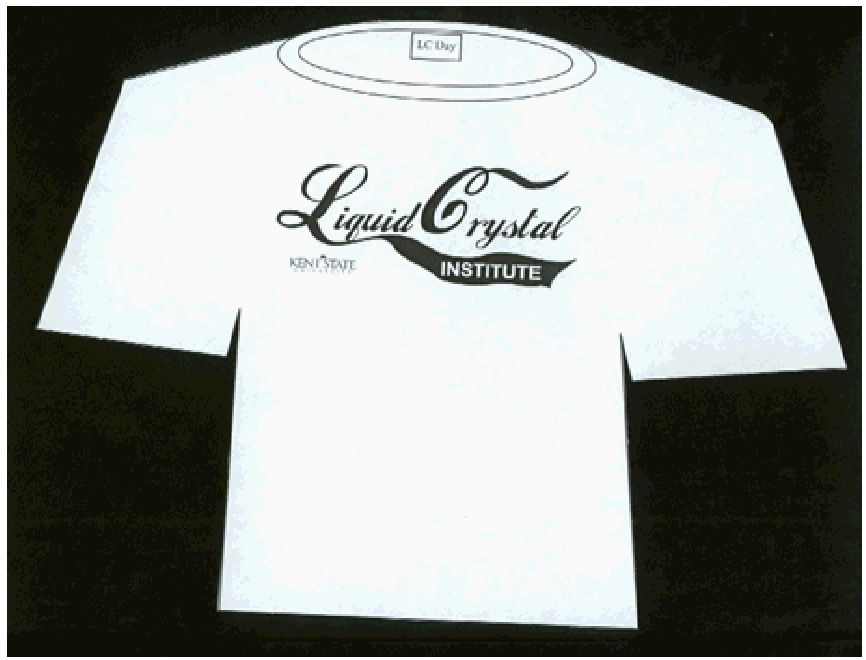
New way to explore science and learn about atoms and molecules via "Digital Dome" experience

http://www.molecularium.com/index.html

features Kid's site, Teacher's Resource Guide offering educational tools that bring nanoscale universe to life.

Rensselaer Polytech. Inst.
NSEC - DMR-0117792, 0642573

Liquid Crystal Day serves to provide platforms for intellectual and enlightening interactions between students and researchers from different academic and professional areas. This annual event was initiated by Professor L.-C. Chien in 2004.



BROADER IMPACTS

Broaden participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)

BROADER IMPACTS

- Broader participation through
  - Inclusion of a diversity of participants, especially women, minorities and people with disabilities
  - Partnerships with 2- and 4-year colleges
  - Minority serving Institutions
  - Industrial collaboration
  - International collaboration

DMR Sponsored Workshops

Goal: to develop a broadly inclusive Materials Research and Education Workforce

- **Materials Science and Engineering Gender Equity Workshop, Adelphi, MD, May 18-20, 2008**

- **Materials Science and Materials Engineering Education Workshop, Arlington, VA, September 18-19, 2008**

- **Workshop on Excellence empowered by a Diverse Academic Workforce: Chemists, Chemical Engineers and Materials Scientists with Disabilities, Arlington, VA, February 8-10, 2009.**

OUTREACH TO DEAF STUDENTS

Peggy Cebe (Tufts U.)

Prof. Cebe recruited undergraduates at Gallaudet U., the nation's University for deaf and hard-of-hearing students.

One group of undergraduates together with faculty and sign-language interpreters at Tufts.

The following year some students gave a poster at a national ACS Meeting, while one student gave an oral presentation using voicing and a sign-language interpreter.

DISTINGUISHED MENTORING

Valerie Ashby (UNC)

THE NEWSMAGAZINE OF THE CHEMICAL WORLD

CHEMICAL & Engineering News

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2002 Go!

Safety Letters
Chemcyclopedia

SCIENCE & TECHNOLOGY

August 26, 2002

Volume 80, Number 34
CENEAR 80 34 p. 34
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WOMEN IN CHEMISTRY

CHEMIST, TEACHER, SCHOLAR, MENTOR

To Iowa State's Valerie Sheares, the value of having and being a mentor is priceless

Valerie V. Sheares, an assistant professor at Iowa State University's department of chemistry in Ames, interviewed for both academic and industry positions before she joined the university in 1996. "When you begin a career in chemistry, academia is the more daring of the two possibilities," she says. "Industry seemed more comfortable to me, but I chose academia. Making that

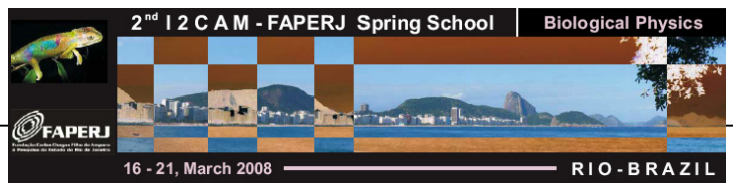
Ms. Dominique Downing (right), recipient of the 2007 NOBCChE Undergraduate Research Award

I2CAM/FAPERJ School on Biological Physics

Daniel L. Cox, University of California, Davis, DMR 0645461

Students and lecturers gather after a day of science

ICAM-I2CAM Institute for Complex Adaptive Matter



Broader Impacts of the School

- The school was part of a two year effort to build our international materials network in South America
- American students were paired as roommates as much as possible with Brazilian ones to help build future collaborations.
- Lectures were filmed and are being archived at the I2CAM web site.
- The school had excellent disciplinary diversity (physics, chemistry,biology, chemical engineering, electrical engineering,bioengineering) and demographic diversity - (among lecturers and students were 33 women,46 from underrepresented ethnic groups)
- After the school, participants from both hemispheres joined up on a Facebook group

International REU Site: Advanced Materials Processing and Analysis in Thailand

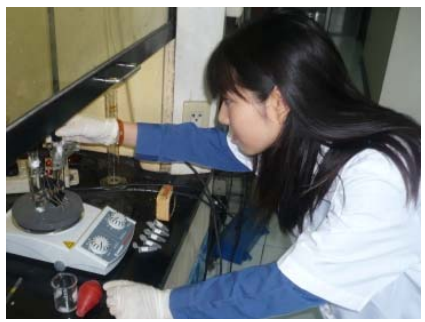
Supapan Seraphin, University of Arizona, DMR 0754632

Katrina McDaniel polishing her sample

Hanh Duong packing TiC-Ni sample

Visiting Thailand National Material Tech Center on June 20, 2008

Nick Hamlin with his heptic device



Apiradee Sanglimsuwan preparing polymers

•*Broader Impacts*

•The benefits of students traveling abroad include personal growth, an understanding of other cultures, open-mindedness, and foreign language appreciation.

•They benefit by being more tolerant and accepting of peoples who are different from themselves; awareness of other cultures' contributions to contemporary life; being prepared to enter the global workforce; and being thoroughly engaged in the shifting demographics of a society that become more ethnically and culturally diverse.

•The program integrates fully the research, education, diversity, and sustainability.

Web Course on Nanoscience and “Nano Boot Camp”

Song Jin (U of Wisconsin-Madison), DMR-Award #0548232

SEM experiment with Jeremy Higgins

Synthesize your own nanomaterials

We have developed a web course on nanoscience & nanotechnology for **school teachers**. As one of the success stories of this course, a former participant, Mr. Joseph Rajkumar from the Conserve School of northern Wisconsin, developed a class on “Introduction to Nanoscience” in Jan 2008. Furthermore, our research group organized and hosted a two-day workshop (called “Nano Boot Camp: Discovering the Nanoscience at UW-Madison”) for the group of high school students taking this class on Jan 14&15, 2008. The students heard introduction talk about nanoscience, toured the research lab and facilities, carried out two lab modules on nanomaterials, and used electron microscope to examine the nanomaterials they made, and also joined a panel discussion about college and graduate study.

CAREER: Robust Thin Film Shape Memory Alloys for MEMS

Ainissa G. Ramirez, Yale University, DMR 0347095

Broad Impact:

Our method of experimentally determining the kinetic parameters of crystallization with TEM, and then plugging these values into the Avrami theory is a paradigm shift in the study of materials. With it, we can now predict microstructure and tailor the associated properties of a film *a priori*. We are now able to correlate microstructure with mechanical properties with our recent nanoindentation studies.

Education:

•Revamped the *Introduction to Materials Science Laboratory* by incorporating modern characterization techniques, such as AFM.

•*Training:* Drs. Hoo-Jeong Lee, Xu Huang, and Hai Ni contributed largely to this work.

•*Collaborations*: Graduate students and their advisors at Ohio State University and Princeton also contributed to this work.

Outreach:

•Compiled a book of materials science classroom demonstrations, called *Demoworks.* The StrangeMatter museum exhibit hosts this resource, which has been downloaded nearly 55,000 times in two years. Find it at: www.strangematterexhibit.com/teachers.html.

•Directed and hosted the award-winning science lecture series for kids called *Science Saturdays (since 2004).* Four lectures of various science topics were held with attendances of over 200 people.

•Serves as an advisor to the NISE Network (Exploratorium /Boston/Minnesota); serves as an advisor to the Liberty Science Center (NJ); DragonFlyTV, and NOVA.

Award/Honors

•MIT's MLK Visiting Professorship

MRS

strange MATTER

Effect Of Alloying And Heat Treatment On The Biaxial Creep Behavior Of Titanium Alloys

K. Linga Murty, North Carolina State University

Project # DMR 0412583

Broader Impact:

- Potential applications for titanium alloys exist in the aerospace, chemical, and biomedical industries. The research will significantly augment our understanding of structure-property correlations in these alloys, and open up new opportunities for their future applications.
- As a part of 'Young Investigators Summer Programs' since 2006, groups of high school students were involved in a two-week long research project assisted by the graduate students supported by this grant. After completion of their project, they presented their research results. This is an ideal way to recruit bright students to science and technology.
- Many undergraduate students have been supported through the related REU supplements. Many of them have shown interest in pursuing graduate studies. Full-time graduate students and a postdoctoral researcher have been contributing towards achieving the project objectives and at the same time, furthering their educational goals.
- Many journal papers and conference presentations have been made through which results are disseminated in the widest possible way.

Summer 2008

Summer 2007

Summer 2006

Broader Impacts: How to go about

- 1 or 2 efforts often come across as stronger than several smaller efforts
- Make it clear what is new & if necessary, how it distinguishes itself from existing efforts
- (do tap in to existing efforts)
- Own track record, references to literature, letters of support, …
- Impact?
- Requirements: 1-2 pp. typical for individual investigator ‘regular’ proposal; ~5 pp. for CAREER proposal

Broader Impacts: Summary

- **Go beyond (i) science impact, (ii) education of graduate students, (iii) publishing and presenting and (iv) teaching**
- **Consider including broadening participation "NSF staff will give [diversity] careful consideration in making funding decisions."**
- **http://www.nsf.gov/pubs/2005/nsf0507/nsf0507.htm**
- **Partnerships, dissemination, ethics, mentoring, undergraduates, radio/TV, museums, K-12, research experiences for teachers (RET), course development, moduli, web-based courses, …**

Conclusions

When it comes to broader impacts

HIGHLIGHT

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MENTOR