NSF Merit Review System

Proposal Evaluation Criteria

Proposals are evaluated based on two criteria:

- Intellectual Merit
- Broader Impacts

I. Intellectual Merit

- Potential to Advance Knowledge & Understanding
- Originality and Creativity of the Proposal
- Transformative Potential of the Proposed Work
- Qualifications of Researchers
- Organizational Capacity
- Access to Resources Needed

What is meant by transformative research?

It is research that has the potential to:

- Revolutionize existing fields
- Create new subfields
- Cause paradigm shifts
- Support discovery
- Lead to radically new technologies

II. Broader Impacts

- Aspects of Teaching and Learning
- Integration of Research and Education
- Infrastructure Development
- Technology Transfer
- Societal Benefits
- Broader participation through
  - Inclusion of a diversity of participants, especially women, minorities and people with disabilities
  - Partnerships with 2- and 4-year colleges
  - Industrial collaboration
  - International collaboration

II. Broader Impacts

- What does “broader impacts” mean?
- Why does “broader impacts” matter?
- How can “broader impacts” be demonstrated?

What does “broader impacts” mean?

- Refers to the important outcomes and consequences of NSF-supported activities

Why does “broader impacts” matter?

- Research supported by DMR yields many results of direct and obvious importance to other disciplines and society
- The materials community is in a strong position to demonstrate creativity and originality in **broader impacts**, as well as **intellectual merit**

How can “broader impacts” be demonstrated?

- General areas* include the followings:
  - Advancing discovery and understanding while promoting teaching, training, and learning
  - Broadening participation of underrepresented groups
  - Enhancing infrastructure for research and education
  - Broadening dissemination to enhance scientific and technological understanding
  - Providing benefits to society

*** Proposals should focus on one or more areas where meaningful contributions could be made**

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

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

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

II. Broadening participation of underrepresented groups*

- Involve underrepresented groups in research and education activities at all levels – from students to faculty members

Examples include:

- Mentoring and outreach to junior faculty, women and minorities as avenues for increasing professional opportunities
- Establishing collaborations with students and faculty from institutions serving women, minorities, and people with disabilities to increase pool of qualified materials scientists
- **Initiating or participating in the development of a diversity strategic plan within the proposer's academic department**

•Underrepresented groups: women, African Americans, American Indians (including Native Alaskans), Hispanics, Native Pacific Islanders, and persons with disabilities

III. Enhance infrastructure of research and education

- Link scientists and programs to enhance the impacts of research activities

Examples include:

- Establishing research collaborations with industry, national labs and international institutions
- Developing new instrumentation, software, computation or data analysis methodologies that have a wide range of applicability and use
- Providing otherwise inaccessible samples of novel materials to other research groups
- Sharing advanced lab or computational methods, instrumentation and software
- Building national and international research and education networks
- Building a cyber-enabled infrastructure to connect research universities with 4- and 2-year colleges, and overseas universities

IV. Broaden dissemination to enhance scientific & technological understanding

- Examples include:
  - Organizing materials research and education workshops and symposia
  - Forging links to other scientific disciplines
  - Writing scholarly articles that go beyond routine research publication or that are addressed specifically to non-specialist audiences
  - Sharing data that may otherwise not be easily accessible
  - Working with science centers on new materials research and education exhibits
  - Assisting journalists with their stories on technical topics
  - Developing new art forms for communicating materials research to wider audiences
  - Creating materials research related websites enhanced by engaging animations and movies to educate non-scientists and the public at large

V. Provide benefits to society

- Communicate to the public the excitement, benefits, and long term impacts of materials research and education

- Enhance public appreciation of the relevance of advanced materials research to the future and society

- Emphasize (wherever and whenever appropriate) technological advances that will profit our economy, benefit our health and increase our national security

Examples include:

  - Creating scientific basis for start-up companies that employ new materials research technologies or generally enhancing the knowledge base for future devices
  - Establishing strong partnerships with industry and developing easy mechanisms for transforming fundamental research findings into useful and practical applications

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Materials Research (DMR)

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Submission Window for Unsolicited Proposals

Starting in 2009, the window for submitting unsolicited proposals to DMR **begins September 1 and ends on October 31,** annually. If the closing date for the submission window falls on a weekend, the closing date moves to the following M The last date of the submission window is an absolute deadline date and proposal be received by NSF by 5:00 p.m. submitter's local time on that date.

The submission window applies to unsolicited proposals submitted to DMR progra except for the following which may be submitted at any time during the year: Gra Rapid Response Research (RAPID), EArly-concept Grants for Exploratory Researc (EAGER), proposals for workshops or conferences, proposals to the DMR National Facilities Program, and supplements to existing grants. For proposals submitted in response to special announcements or solicitations, the deadline dates specified in the announcement or solicitation apply.

We strongly advise Principal Investigators and Sponsored Research Offices to submit early and avoid a last-minute rush, which can cause problems in timely and correct transmission to NSF. Proposals that have formatting problems or are otherwise non-compliant with the Grant Proposal Guide, http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg, can usually be corrected and resubmitted within the same window if received early; there may be no time to do that for proposals submitted close to the deadline date.

DMR discourages the submission of more than one proposal from the same Principal Investigator during the proposal-submission window.

Perspective on Broader Impact Review Criteria

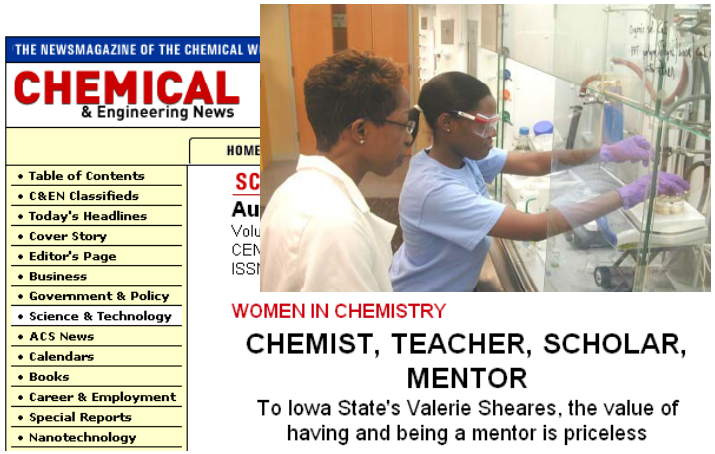
View the DMR Dear Colleague Letter for more information.

Special Announcements

Link to DMR Dear Colleague Letter

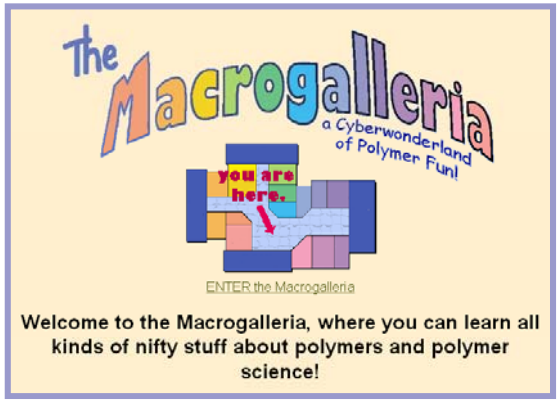
www.nsf.gov/materials

DMR POLYMERS PROGRAM : SOME EXAMPLES OF BROADER IMPACTS



Renowned mentor Valerie Sheares (now at UNC)

First REU Site for deaf and hard-of-hearing students. (Peggy Cebe, Tufts U.)



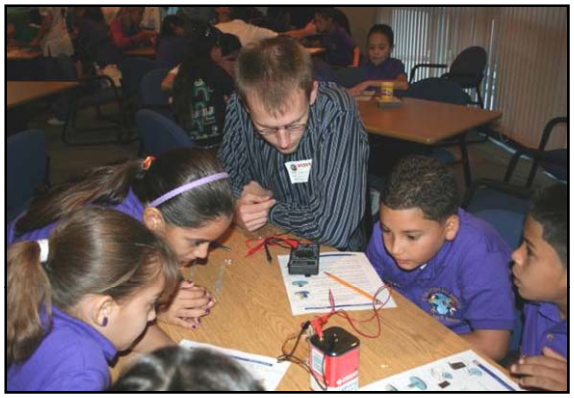
One of the top educational websites, translated into 6 languages, winner of many educational awards. (Lon Mathias, USM)

Highly successful materials science museum exhibit – has been to 30 museums in US and abroad. (Shenda Baker, Harvey Mudd College)

Bringing Hands-on Science to Schools Across the Nation

Educational modules developed in Upstate NY benefit teachers and students in Puerto Rico

Over the past 10 years, researchers at Cornell University have developed hundreds of hands-on activities that bring the excitement of science into the classroom. To increase their impact, Cornell is partnering with colleagues at Arecibo Observatory and the University of Puerto Rico (UPR) to bring their expertise south. This spring, the two groups ran a joint workshop for elementary school teachers on the UPR campus in Mayagüez. At the one-day workshop, teachers learned new ways to integrate microscopy into elementary education and received supplies for materials-focused classroom activities. At Arecibo Observatory, Cornell grad students taught elementary students from around the Island about energy and fuel cells. During the session, the students enthusiastically collaborated to build their own battery-powered electrolyzers. The real excitement came when the students disconnected the batteries and learned to make their own energy!



Clockwise: Cornell graduate student John Gregoire testing the students' fuel cell. Cornell graduate student Alejandra Andere-Jones explaining a materials-focused microscopy experiment to Puerto Rican teachers. Students ready to explore materials.

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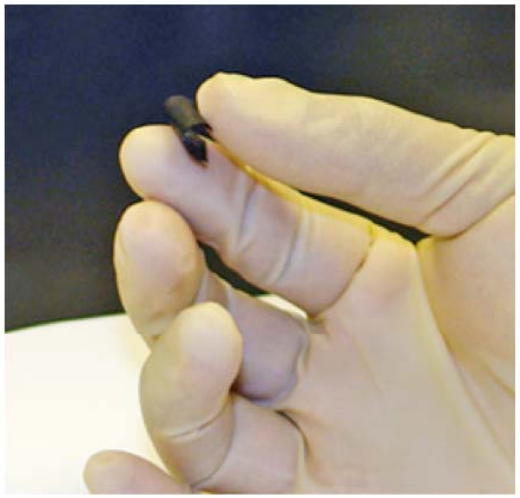
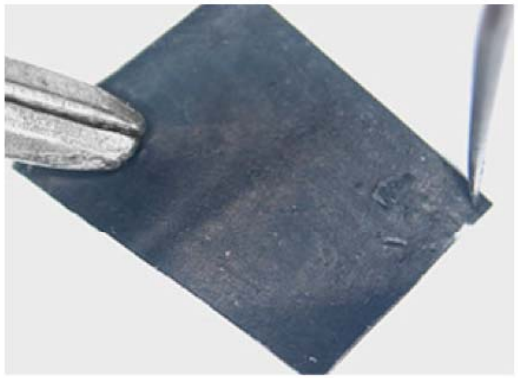
The Paper Battery Company, Inc. Formed to Capitalize on Technology Developed at RPI's NSEC





NSEC researchers at RPI have nanoengineered a lightweight, ultra-thin paper battery geared toward meeting the demanding design and energy requirements of tomorrow's electronic and electrical apparatus. Over 90 percent of the device is cellulose that has been infused with aligned carbon nanotubes that act as electrodes and enable electrical conduction. The battery is completely integrated - its components are attached molecularly to each other - and can be printed like paper. It can be rolled, twisted, folded, or cut into any shape with no loss of mechanical integrity or electrical efficiency. Battery sheets can be stacked - like printer paper - to boost the total energy and, significantly, the devices can function either as high-energy batteries or high-power supercapacitors.

A patent has been filed to protect the technology and The Paper Battery Company, Inc. has been formed to engineer the paper-based super-capacitors and batteries from a common starting sheet of nanocomposite material made in a high volume process. The company's vision is to develop and market the next generation of storage devices and set a standard for clean, renewable energy.

UW MRSEC Interdisciplinary Education Group Utilizes Museum Partnership to Increase Dissemination of Educational Materials

Juan J. de Pablo and Greta M. Zenner, University of Wisconsin MRSEC (DMR #0520527)

The partnership between the University of Wisconsin – Madison (UW) Materials Research Science and Engineering Center (MRSEC) on Nanostructured Interfaces and the Nanoscale Informal Science Education Network (NISE Net) has resulted in national dissemination of numerous outreach activities developed by the MRSEC Interdisciplinary Education Group (IEG).

NanoDays, a week of nanotechnology-related public outreach events sponsored by the NISE Net, is an annual event occurring each spring. To encourage museum and informal science education educators to participate in NanoDays, NISE Net created and distributed 100 kits containing background information and all materials necessary to lead six different nanotechnology-related activities. Three of the six activities included in the 2008 kits were adapted from educational materials created by the IEG. A diverse group of institutions from across the country received the kits, including museums, public libraries, and university research centers. 150 educators also downloaded electronic versions of the NanoDays activities from the NISE Net website. NanoDays proved to be extremely successful, and the MRSEC-developed program about balloon models of carbon nanotubes was so popular that the country sold out of the black balloons needed to lead the activity. For the upcoming 2009 NanoDays, the number of distributed physical kits was doubled to 200, and a fourth UW MRSEC-developed activity was added.

The UW MRSEC has also contributed eight programs to the NISE Net's open-source, online catalog (www.nisenet.org). The programs already posted to the online catalog are: Balloon Nanotubes (tabletop version and large suspended sculpture), Forms of Carbon, Magic Sand, Lotus Leaf Effect, Cutting It Down To Nano, and Nanostained Glass (cart demo and classroom version).

In addition to providing education materials to the NISE Net, IEG staff Greta Zenner (director) and Kimberly Duncan (postdoctoral associate) co-planned and co-led a series of regional training workshops with NISE Net partners during fall 2008 and winter 2009. The workshops aimed to further prepare informal educators to present nanotechnology-based programming at their institutions. Approximately 140 educators attended the seven workshops held at the Science Museum of Minnesota (St. Paul, MN); the North Carolina Museum of Life and Science (Durham, NC); Sciencenter (Ithaca, NY); Oregon Museum of Science and Industry (Portland, OR); Lawrence Hall of Science (Berkeley, CA); The Franklin (Philadelphia, PA); and the Ft. Worth Museum of Science and History (Ft. Worth, TX). Zenner and Duncan facilitated the sessions aimed at encouraging museum educators to partner with local research centers, gave introductory presentations on nanotechnology, and trained workshop attendees to lead the UW MRSEC-developed program about balloon models of carbon nanotubes. A workshop kit was sent to workshop attendees, which included electronic copies of the Intro to Nano presentation and, for those who chose to receive it, materials for the carbon nanotube balloon program. The institutions who had individuals attend the workshops are required to lead NISE Net programming in their museum, which included the programs developed by the UW MRSEC.

Attendees of the NISE Net regional workshop at the Oregon Museum of Science and Industry learn to build a giant suspended model of a carbon nanotube out of balloons and to talk with visitors about carbon nanotubes. The program was developed by UW MRSEC.

UW MRSEC IEG director Greta Zenner trains attendees of the NISE Net regional workshop at the Science Museum of Minnesota to lead the Giant Carbon Nanotube Balloon program.

This work was supported by the NSF through the University of Wisconsin Materials Research Science and Engineering Center, grant number DMR-0520527.

University of Wisconsin MRSEC Extends Reach of their Education Program through NISE-Net

The University of Wisconsin MRSEC Interdisciplinary Education Group staff Greta Zenner (director) and Kimberly Duncan (postdoctoral associate) co-planned and co-led a series of regional training workshops with Nanoscale Informal Science Education Network (NISE Net) partners during fall 2008 and winter 2009. The workshops aimed to further prepare informal educators to present nanotechnology-based programming at their institutions. Approximately 140 educators attended the seven workshops

Zenner and Duncan facilitated the sessions aimed at encouraging museum educators to partner with local research centers and gave introductory presentations on nanotechnology. They trained workshop attendees to lead Wisconsin MRSEC-developed educational materials, such as the balloon models of carbon nanotubes shown here.

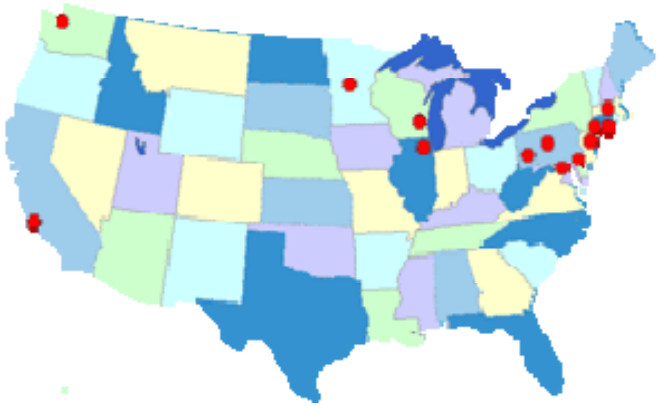
University of Wisconsin MRSEC (DMR-0520527)

NISE Net regional workshop at the Oregon Museum of Science

NISE Net regional workshop at the Science Museum of Minnesota.

NSF-DMR05-20415

Materials Research Facilities Network

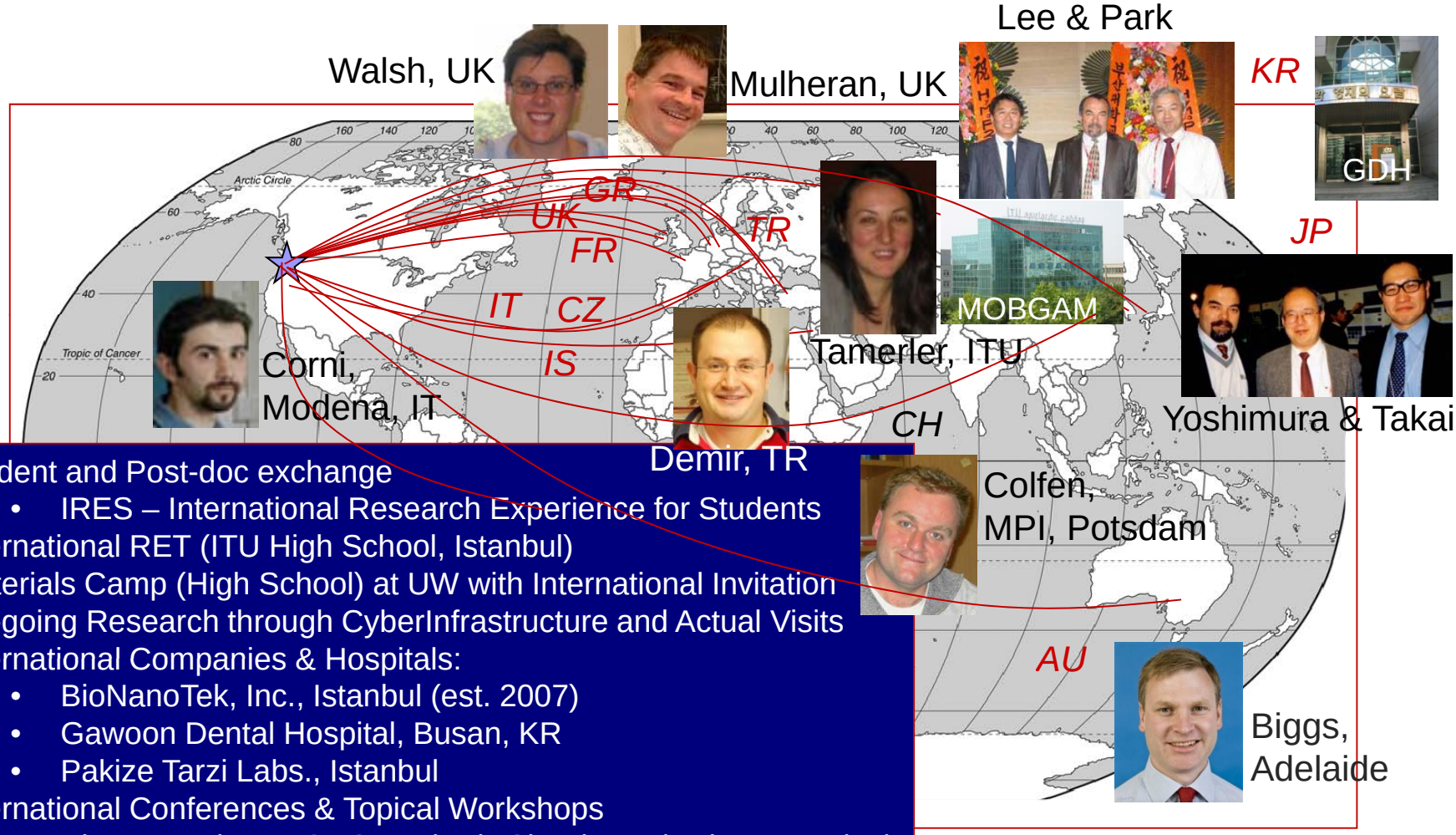


The Materials Research Facilities Network (MRFN) has recently been established and is currently in operation at ca. 50% of MRSEC sites. The goal of the MRFN is to maximize the usage of MRSEC facilities and is directed towards the efficient and strategic development of materials characterization within the United States. By providing easy access through its wide geographical distribution to small and large universities not in the MRSEC program, the MRFN will substantially contribute to the education and mentoring of a wide diversity of students and further promote collaborative research in materials.

MRFN A National Research and Education Resource

Anika Odukale, Craig Hawker

INTERNATIONAL ACTIVITIES & PARTNERSHIPS



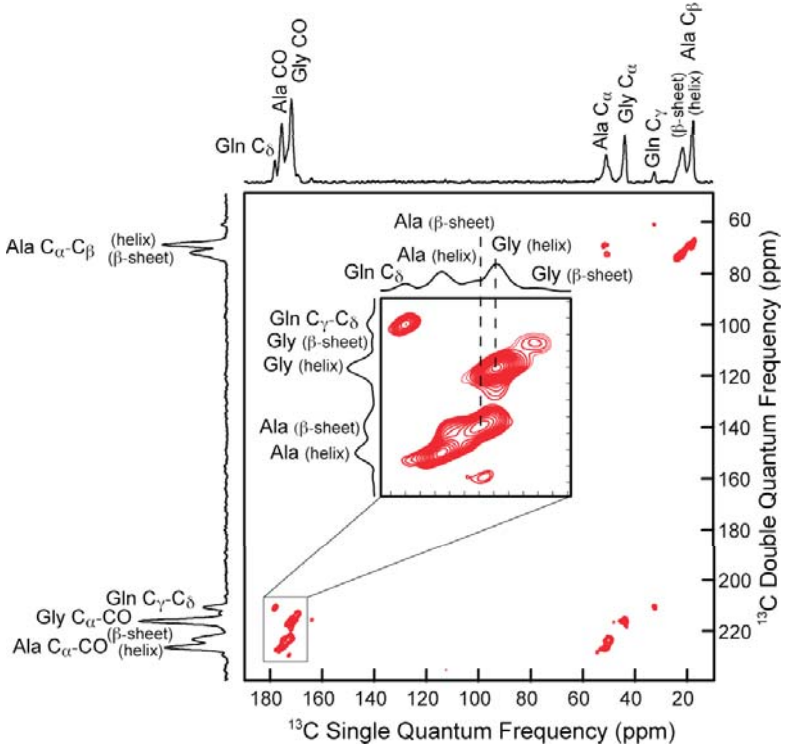
- Student and Post-doc exchange
  - IRES – International Research Experience for Students
- International RET (ITU High School, Istanbul)
- Materials Camp (High School) at UW with International Invitation
- On-going Research through CyberInfrastructure and Actual Visits
- International Companies & Hospitals:
  - BioNanoTek, Inc., Istanbul (est. 2007)
  - Gawoon Dental Hospital, Busan, KR
  - Pakize Tarzi Labs., Istanbul
- International Conferences & Topical Workshops
  - Bionanotech at MOBGAM (TR), SimBioMa (UK); BMMT (JP)
  - Annual GEMSEC Workshop

Supported by NSF via GEMSEC, MRSEC at UW (DMR-0520567).

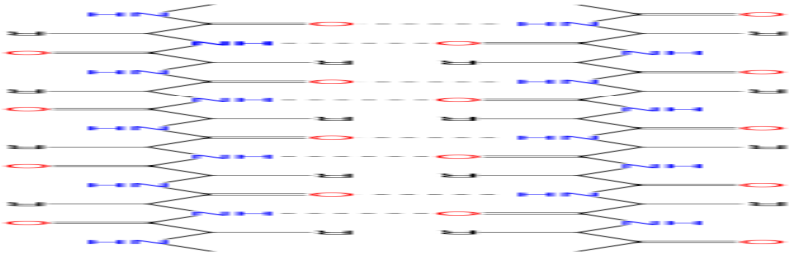
Dynamical & Structural Studies of Spider Silk Fibers

Jeff L. Yarger & Greg P. Holland, Arizona State University, DMR-0805197

Spider silk has a unique combination of mechanical properties that make it one of the toughest materials known. The research team at ASU, led by Prof. Yarger and Holland, have used solid-state Nuclear Magnetic Resonance (NMR) spectroscopy to probe the structural features responsible for the silk's strength. Specifically, we use an incredible natural abundance double quantum transfer experiment (INADEQUATE) NMR method (*right*) to elucidate the helical and parallel vs. anti-parallel β-sheet components (*bottom*) in Black Widow (*top left*) spider silk fibers.



Parallel β-sheet, Free CH_3 rotation



Anti-parallel β-sheet, Restricted CH_3 rotation

Dynamical & Structural Studies of Spider Silk Fibers

Jeff L. Yarger & Greg P. Holland, Arizona State University, DMR-0805197

Spider Silk Research Group Collage.

The National Science Foundation, Division of Material Research, Biomaterials (BMAT) grant at awarded to Profs Yarger and Holland at Arizona State University is being used to support undergraduate students, graduate students, and support high school biology and chemistry teachers for summer research projects. Participants include several women and underrepresented minorities. Pictures show several of the undergraduate and graduate students involved in the project, including a picture of Paul Akhenblit, an undergraduate student at ASU, feeding a spider isotopically enriched amino acids (lower left).

Current NMR elucidation of spider silk structure will greatly advance the ability of synthetic mimics to be produced and used as medical and biological scaffolds.

The grinding tip of the sea urchin tooth: exquisite control over calcite crystal orientation and Mg distribution

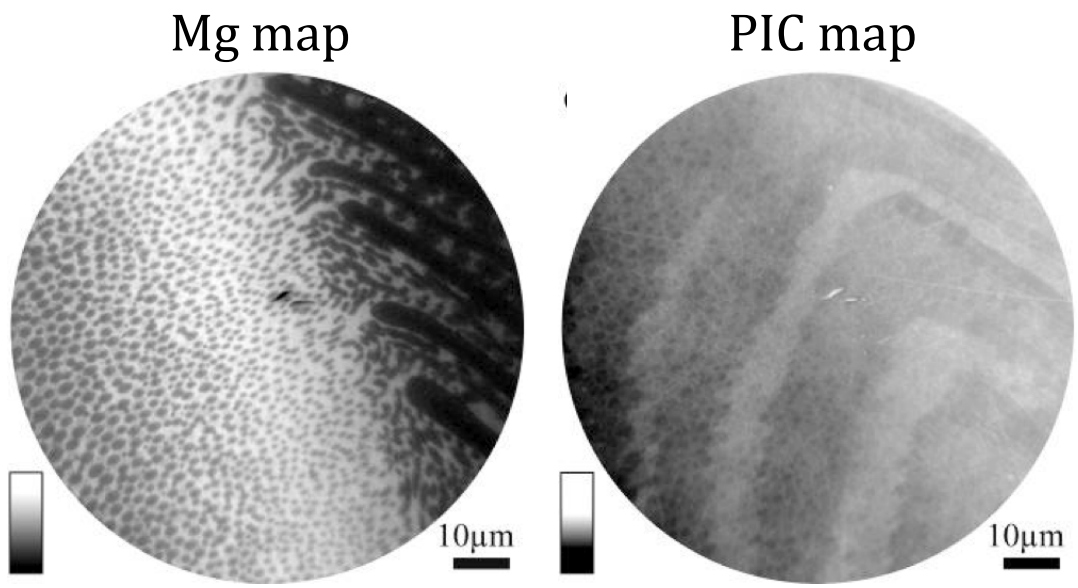
Pupa Gilbert, University of Wisconsin-Madison,

Award number: CHE-0613972 co-funded by DMR/BMAT (ACI-Award)

Sea urchins use their teeth to bite food and grind rock. Their teeth are intricately shaped, highly co-oriented calcite crystals, which self-sharpen with use. How can they be made of calcite, yet grind limestone, which is also largely made of calcite?

The key is in their morphology at the nano-to-centimeter scale, crystal orientation, and Mg-substitution in the calcite crystals.

The Mediterranean urchin
Paracentrotus lividus



Magnesium (Mg) and polarization-dependent imaging conrtrast (PIC) maps obtained by synchrotron spectromicroscopy, from a cross-section of *P. lividus* tooth. The exact same region is imaged in both maps. In the Mg map, white indicates high Mg concentration, thus the elongated plates and the small elliptical needles appear black, while the high-Mg matrix cementing plates and needles together is white. In the PIC map different gray levels indicate different crystal orientations. Notice that 2 blocks of crystals alternate, each including 1 plate, many needles, and the matrix in between.

Procs. Natl. Acad. Sci. USA 106, 6048-6053 (2009).
New York Times, March 31st, 2009
http://www.nytimes.com/2009/03/31/science/31oburchin.html

The grinding tip of the sea urchin tooth: exquisite control over calcite crystal orientation and Mg distribution

Pupa Gilbert, University of Wisconsin-Madison,

Award number: CHE-0613972 co-funded by DMR/BMAT (ACI-Award)

Outreach:

We present our research on biominerals to 3000 people from the general public attending the UW-Madison Physics Fair. This year (Feb. 14, 2009) the PI and undergraduate student Ian C. Olson had a very successful hands-on experience, which attracted and entertained many hundreds. We encouraged people to break calcite and aragonite 2-mm thick crystals using a diamond scribe, which they could do easily. Then we encouraged them to try to break an abalone shell made of the same minerals and with the same thickness, and they could not.

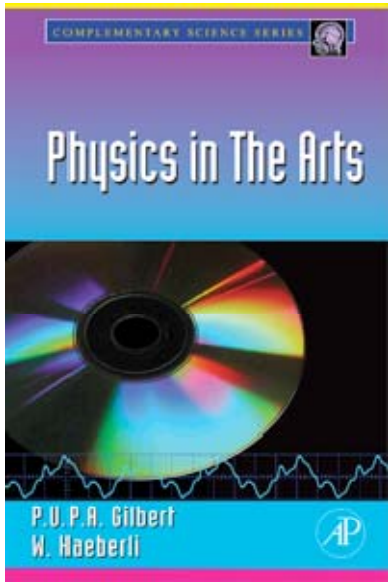
The kids went crazy over this one!

We explained that the microstructure is the trick the shell uses, and showed its structure in a continuously rotating 3D projection of SEM images of abalone nacre, while they wore cyan-red glasses.

Unfortunately we were so busy entertaining people that we forgot to take any photos of them.

Education:

Two undergraduates (Ian C, Olson and C. Kyle Miller, three graduate students (Rebecca Metzler, Dong Zhou, Yutao Gong), one post-doc (Dr. Christopher E. Killian) and one staff scientist (Dr. Narayan Appathurai) participate in research under Gilbert's guidance.



Gilbert teaches Physics in the Arts to 260 non-science college students, and wrote the above book for the general audience.

She is fully committed to communicating the principles of physics and biomaterials at a level that everybody can understand, independent of age and education, without ever sacrificing accuracy.