Materials Institutes Weave Global Networks

Six NSF-funded materials science institutes are working to train a new generation of internationally minded US researchers and to stimulate collaborations around the world.

A dentist in Alexandria, Egypt, seeks a replacement for decaying bone. To that end, a sol–gel chemist in Lisbon, Portugal, is working to create glass structures with continuous porosity that would let cells and nanofibers grow and nutrients flow. The structures will be characterized by scientists at Lehigh University in Bethlehem, Pennsylvania, and the interface between the candidate bone replacement and biological tissue will be investigated in Senegal and at Princeton University.

This collaboration, involving researchers in four countries on three continents, is the type of activity that NSF wants to facilitate with its International Materials Institutes program. NSF is funding six IMIs—three were launched in February 2003 and three a year and a half later—with the aims of stimulating a global network in materials science and training a new generation of internationally competitive materials scientists and engineers.

"We would like [the IMIs] to develop into nodes of materials researchers that would interact with each other. This is a long-term project," says NSF's Carmen Huber, who oversees the IMI program. "We would like US students to be competitive in an international arena. In that regard, having international experience will be useful. It's a new model for NSF."

The IMIs each receive between $3 million and $3.5 million over five years. The six institutes are similar in their amorphous structure and many of their activities, including funding international exchanges of scientists to and from the US; organizing and supporting workshops, conferences, summer schools, and college and precollege educational programs; setting up web-based interactions and shared databases; and cultivating interpersonal networks. But their guiding themes vary from focusing on material, technique, or region, to broadly embracing materials science topics around the world.

From fiber bricks to informatics

The US–Africa Materials Institute (USAMI)—which, along with the International Materials Institute for New Functionality in Glasses, is involved in the bone replacement project—has so far coordinated 40 or so visits back and forth among its network of about 10 groups in the US and 20 countries across Africa. Says institute director Wolé Soboyejo, a materials engineer at Princeton, "We try to bring the same people back several times. We find it takes time to build relations and learn the ropes." As with exchanges organized by the other IMIs, lab stays tend to be several months long.

Affordable housing and advanced materials are USAMI's research focuses. On the housing side, examples include studying viscoelastic toughening and thermal properties of local clays and aluminosilicates and looking at the strength and fracture mechanics of composite bricks that incorporate natural fibers. On the advanced materials side, making solar cells and light-emitting diodes are projects that involve synthesizing new polymers and developing methods of pattern transfer with organic electronics, which—unlike silicon—do not require access to clean rooms. Says Soboyejo, "It's important for Africa to get involved in advanced materials research. Otherwise, the gap between the rest of the world and Africa will increase with time."

The glass institute has six research thrusts: glassy meta-materials and nanocomposites, functional coatings, and glasses engineered for strength, ionic functionality, optical functionality, and biofunctionality. Among the IMIs, it has perhaps the closest ties to industry. For example, says institute director Himanshu Jain of Lehigh University, international industry leaders are invited to "help identify 10 or 15 key scientific questions they would like answered and which are important for new applications." Like the glass institute, the International Institute for Complex Adaptive Matter, or I2CAM, is centered on specific research areas, in this case biological matter and correlated electron systems.

The Advanced Neutron Scattering Network for Education and Research aims to attract and train US scientists in a field the country lags behind in: neutron science. That is especially important, says director Peter Liaw of the University

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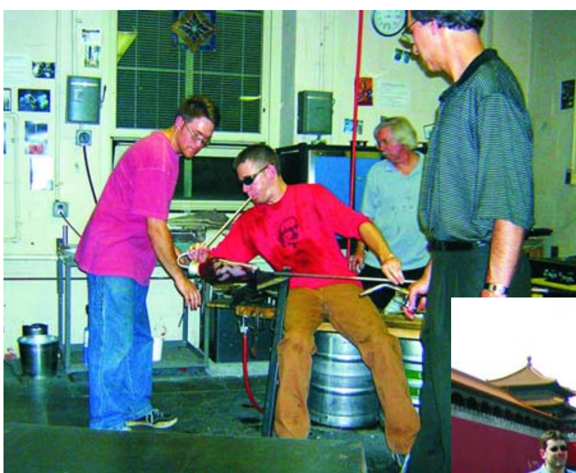

ICMR-UCSB

Glass blowing was part of a public open house (above) held last February by the International Materials Institute for New Functionality in Glasses. Participants in a workshop in China last May, organized by the International Center for Materials Research, took a break to tour Beijing's Forbidden City.

of Tennessee, “to take advantage when the $1.4 billion Spallation Neutron Source comes along.” The SNS at Oak Ridge National Laboratory is scheduled to become fully operational in 2008. The Combinatorial Sciences and Materials Informatics Collaboratory (CoSMIC) focuses on exploiting informatics to design materials.

Unlike the other IMIs, the International Center for Materials Research does not set itself a geographical, technique, or research focus. “Ambassadors” in many countries identify promising students and researchers for exchanges and collaborations, and anyone can apply for ICMR money to travel to or from the US to take part in a materials science collaboration, says director Anthony Cheetham of the University of California, Santa Barbara. “One of the motivations is to give young American scientists more of an international experience during their education, so we have set aside a lot of our funding for that.”

Last November in Singapore the ICMR launched a program designed to give materials scientists from developing countries in Asia access to regional facilities—“characterization facilities, nuclear magnetic resonance, x-ray diffraction, fablabs, things like that,” says Cheetham. “What I would like [the ICMR] to grow into in the fullness of time is a materials science equivalent to the ICTP [International Centre for Theoretical Physics in Trieste, Italy].”

A measure of success

The idea is for the IMIs to catalyze lasting collaborations that benefit both the US and partner countries. NSF won’t mind if the IMIs create cracks in the insular attitude typical in the US. “People with diverse training and international experience have a better chance of getting a job,” says Tom Weber, director of NSF’s division of materials research. Hahn Choo, a codirector of the neutron institute, tells of one student who had never left eastern Tennessee before spending time at ISIS, the UK’s pulsed neutron source: “It’s eye opening. And if they have this eye-opening experience when they are young, it has greater impact,” says Choo.

In an attempt to measure their impact, the IMIs keep tabs on such things as the numbers of exchanges they fund and workshops they hold and whether their techniques are catching on. “Informatics allows you to take massive amounts of seemingly unconnected information, seek and find relationships, and then make predictions,” says CoSMIC director Krishna Rajan of Iowa State University. “If we can proselytize our approach so that others make it part of their day-to-day methods, that would be a measure of success.” Adds I2CAM director Daniel Cox, “Are our workshops and exchanges generating collaborations, papers, proposals for new work? Are people using our website? Have we nucleated new science that wouldn’t have happened otherwise?”

“The IMIs are not glamorous,” says Cheetham. “There are no big events. It’s small things—but small things can have quite a lot of impact.”

Toni Feder

Stronger Future for Nuclear Power

Nuclear reactor builders are jostling for business as energy utilities take another look at nuclear power.

Some two dozen power plants are scheduled to be built or refurbished during the next five years in Canada, China, several European Union countries, India, Iran, Pakistan, Russia, and South Africa. In the US and the UK, governmental preparations are under way that may lead to 15 new reactor orders by 2007.

About 16% of the world’s electricity supply comes from nuclear power, and energy demand is increasing (see Physics Today, April 2002, page 54). Worldwide, nearly 80% of the 441 commercial nuclear reactors currently in operation are more than 15 years old. To maintain nuclear power’s position in the overall energy mix, new reactors will have to replace decommissioned ones, says a report from the Paris-based International Energy Agency.

The new interest in civilian nuclear energy results from some heavy lobbying by groups involved in building reactors, says Edwin Lyman of the Union of Concerned Scientists, and from attempts to reduce carbon-dioxide emissions. EU Energy Commissioner Andris Piebalgs adds that there are also increasing concerns about energy security, particularly in light of the recent disruption of Russian gas supplies in Europe.

Most of the new reactor designs are third-generation pressurized-water reactors (PWR), although companies in China, France, and South Africa are looking to build a fourth-generation