by Nancy Forbes

# Ideas for Industry Spring from Rice

Rice University's interdisciplinary research centers form a focal point for the exchange of ideas between industry and academe, in addition to serving the school's more than 2,700 undergraduate and 1,500 graduate students. Partnerships with industry have been an integral part of the success of many of these centers, enabling them to work on real-world problems relevant to today's basic and applied R&D agenda.

Tommy LaVergne

**Figure 1. Cynthia Kuper, who worked as a postdoctoral fellow in Rice's Center for Nanoscale Science and Technology, is now president of Versilant Technologies, formed in 2001 to build superstrong materials from carbon nanotubes.**

One of the most active centers on Rice's Houston, Texas, campus is the Computer and Information Technology Institute (CITI), founded in 1987. CITI fosters multidisciplinary research and educational projects between Rice and its industry and government partners in computing technologies, computational engineering, and information processing theory, says director Moshe Vardi. More than 100 faculty members from its core departments of computer science, statistics, computational and applied math, and electrical and computer engineering participate in CITI, as do researchers from chemistry, physics, biochemistry, chemical and mechanical engineering, and space physics.

"At CITI, we aim to predict the future by creating it," says Vardi. "So it is crucial for us to understand where industry is at today, to make sure that the problems we are working on are significant ones. We make intense efforts to involve industry, through our departmental corporate-affiliate program, and we have research agreements with companies such as Compaq, IBM, and Intel, and long-term partnerships with firms such as Schlumberger."

CITI encourages its partners to sponsor research grants in emerging areas of commercial interest. For example, it is currently involved in a three-year project with Texas Instruments, Inc. (TI), in Dallas, Texas, in digital signal processing (DSP). "Over the years, Rice University and Texas Instruments have collaborated on numerous programs designed to share research findings, teach students, and investigate methods for DSP improvements," says Gene Franz, a DSP Fellow at TI. "This relationship is designed for the education of students and practicing engineers. CITI offers communications, DSP, and VLSI [very large-scale integrated circuit] courses to both, and provides hands-on teaching for students regarding design concepts and the building of high-speed interfaces with TI DSP products." CITI also partners with companies in government research projects, such as those sponsored by the Defense Advanced Research Projects Agency.

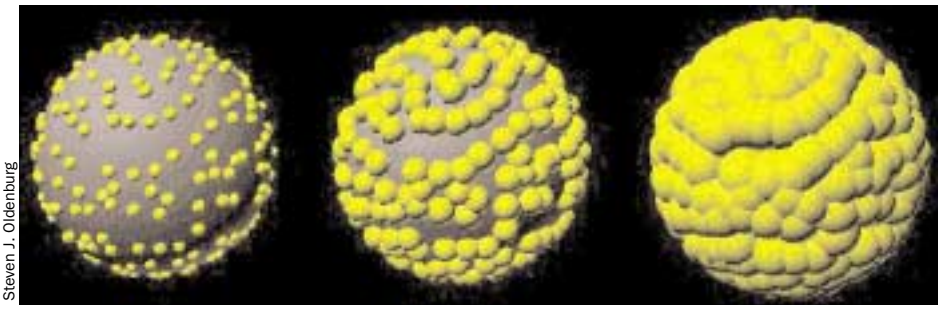
The advantage of industry-academic (I/A) partnerships—in addition to giving industry access to state-of-the-art research and instrumentation—is that they may cost a company less than if it had carried out the research completely in-house.

Vardi says that industry input helps university researchers to better focus on the long-term, fundamental information-technology (IT) research needs of the United States, and that industrial partners also benefit from the insights, contacts, and early access to new information provided by interactions with Rice's faculty.

Compaq, Inc. (Houston, TX), is in the process of renewing a successful two-year collaborative agreement with CITI. "For us, the real fruit is their good ideas, which we always need," says Bob Morgan, a principal member of the technical staff at Compaq. "In industry, we are very product-focused and less prone to take risks with R&D because we need to know that our products will work. Rice can provide us with higher-risk/higher-payoff ideas that may or may not work, which we cannot do on our own. Their real strength is that they take a very practical approach to theory." In addition to the collaborative work at Rice, Compaq encourages the free flow of ideas between Rice faculty and its staff by inviting CITI scientists to give talks at the company and plans to recruit more Rice graduates.

CITI collaborates as well on projects with Nokia, Exxon, Conoco, Amoco, and Shell. Vardi says that the center's main challenge is choosing from among the many promising research directions and balancing long-term academic research goals with those of industry, which tends to focus its work primarily on the near-term. Another challenge is to get students integrally involved in center research projects. CITI has succeeded "in making IT one of the strategic research priorities of Rice," says Vardi. "IT research currently brings in about 25% of Rice's total research support."

Shriram Krishnamurti, a faculty member in Brown University's computer science department, earned his Ph.D. from Rice. He remembers CITI, "as a constant, posi-



Steven J. Oldenburg

**Figure 2. Metal nanoshells—composite layered nanoparticles whose color is determined by controlling the thickness of the layers—are being developed in a collaboration between the Rice Quantum Institute, the Halas Nanoengineering Group, and the physics and bioengineering departments. Here we see the growth stages of gold shells around silica nanoparticles.**

tive presence in the department. They sponsored events and brought in speakers who greatly expanded the department's world view. This was particularly helpful to a budding faculty member, because it helped me see aspects of computer science that I had never paid attention to before. I think CITI played a notable guiding role in shaping graduate students, though often in ways that were not immediately apparent."

With the founding of the Center for Nanoscale Science and Technology (CNST) in 1996, Rice moved to the forefront of an important and burgeoning new field of research: nanoscience and technology. The field is a multidisciplinary endeavor—encompassing such disparate areas as medicine, environmental science, energy, pharmacology, computing, electronics, solar power, and manufacturing processes. More than one-quarter of Rice's technical faculty is already working in this field. The center is headed by Richard Smalley, who shared the 1996 Nobel Prize in Chemistry for his pioneering work in discovering and developing $C_{60}$, the geodesic-dome-shaped molecules commonly called "buckyballs," and the larger class of all-carbon structures called "fullerenes."

Smalley's work at the CNST now focuses on carbon nanotubes, which are a new generation of fullerenes that are stronger than steel and excellent conductors of electricity. Carbon nanotubes already show promise as conducting nanowires in molecular electronics and in instruments for probing the interior of cells. Other applications under investigation could help alleviate some of the world's most pressing problems.

"Nanoscale science holds the key to developing efficient new ways to harness energy from the sun, create strong, lightweight building materials (Figure 1), prevent the spread of deadly viruses, shrink the size and increase the speed of computing devices, and realize many other useful applications—all produced with little or no waste or pollution," Smalley says. Centers such as the CNST are "fundamental to carrying out the research underlying these innovations," he adds. The CNST has already formed productive working relationships with outside organizations and companies that include the Texas Medical Center, the Johnson Space Center, and innovative electronics firms in the Southwest.

The Rice Quantum Institute (RQI) is based on the premise that a great deal of today's frontier research in science and technology is multidisciplinary. RQI's goal is to "foster and facilitate these collaborations," says physicist Peter Nordlander, its director. The center's research portfolio encompasses work in Bose-Einstein condensates, carbon nanotubes, molecular computing, wavelets, quantum chemistry, condensed-matter physics, laser science, terahertz radiation, and molecular spectroscopy. RQI specializes in research that "transcends the traditional boundaries of single departments," says Nordlander, who considers industrial collaborations to be an integral part of RQI's multidisciplinary philosophy. These partnerships take the form of inviting industrial scientists to give colloquia, seminars, and recruiting talks, such as a recent presentation on entrepreneurship given by Milton Chang, the CEO of New Focus, Inc., a successful high-tech start-up company.

Students participate fully in RQI projects and gain exposure to researchers from different backgrounds and with different approaches, which gives students "a pretty big tool box that may come in handy after graduation," declares Nordlander. He says that the center has built a reputation that attracts top-quality graduate students and faculty. RQI has such a broad array of exciting research projects, "that the most difficult thing about being director is keeping track of what everybody is doing" (Figure 2).

With its panoply of multidisciplinary research centers, Rice University has developed a clear vision of the ways in which basic and applied science will help shape the future. Pursuing active synergies with industry is a vital part of this goal.

## RICE UNIVERSITY'S R&D CENTERS

**Most of these are based on the Houston campus, encompassing a wide array of research areas.**

- **Center for Computational Geophysics**
- **Center for High Performance Software Research**
- **Center for Nanoscale Science and Technology**
- **Center for Technology in Teaching and Learning**
- **Center for the Study of Science and Technology**
- **Center for Research on Parallel Computation**
- **Computer and Information Technology Institute**
- **Energy and Environmental Systems Institute**
- **Institute of Biosciences and Bioengineering**
- **Rice Alliance for Technology and Entrepreneurship**
- **Rice Quantum Institute**
- **Rice Space Institute**
- **Engineering Design and Development Institute**
- **W. M. Keck Center for Computational Biology**