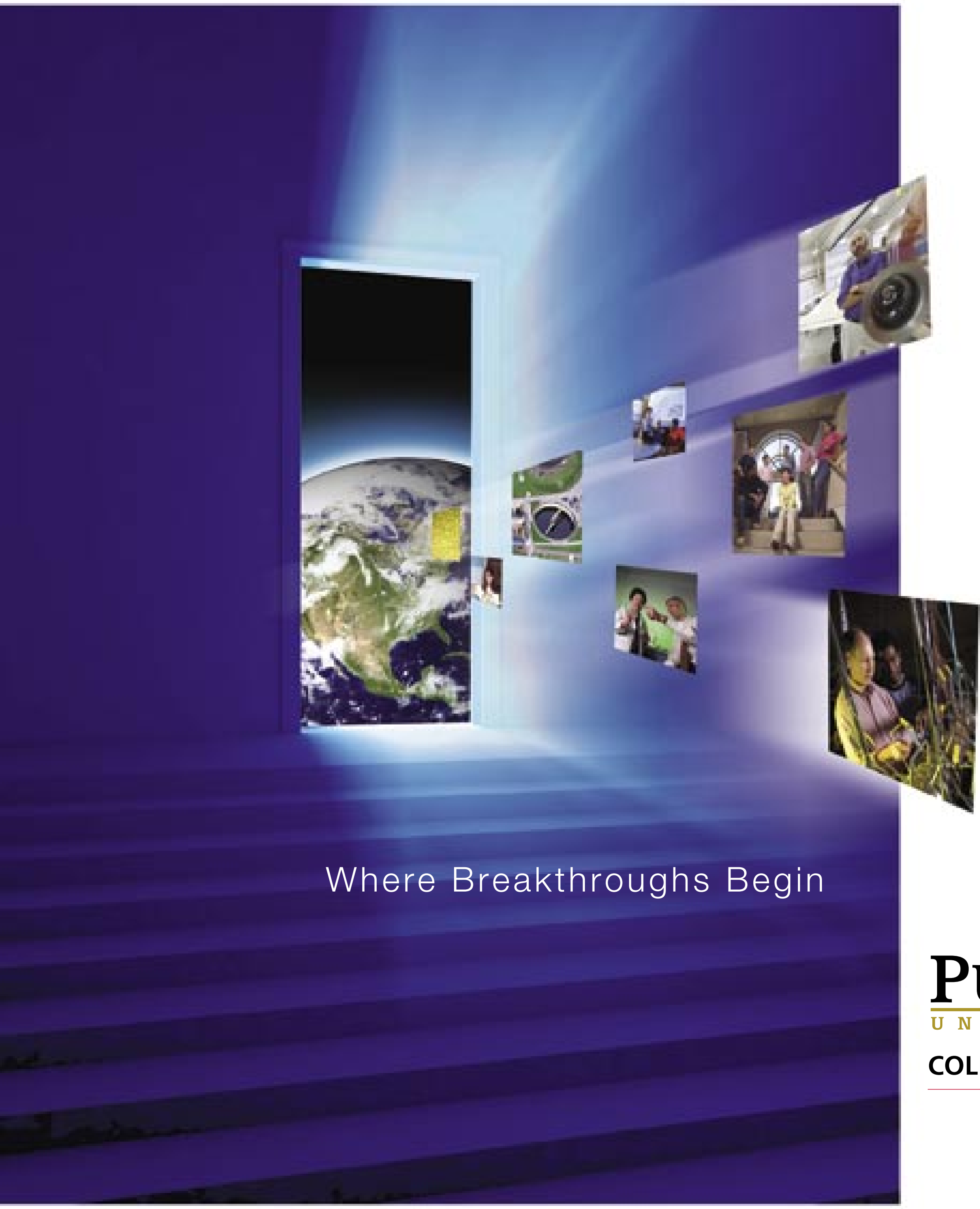
PURDUE'S ENGINEERING EDGE



PURDUE UNIVERSITY

COLLEGE OF ENGINEERING

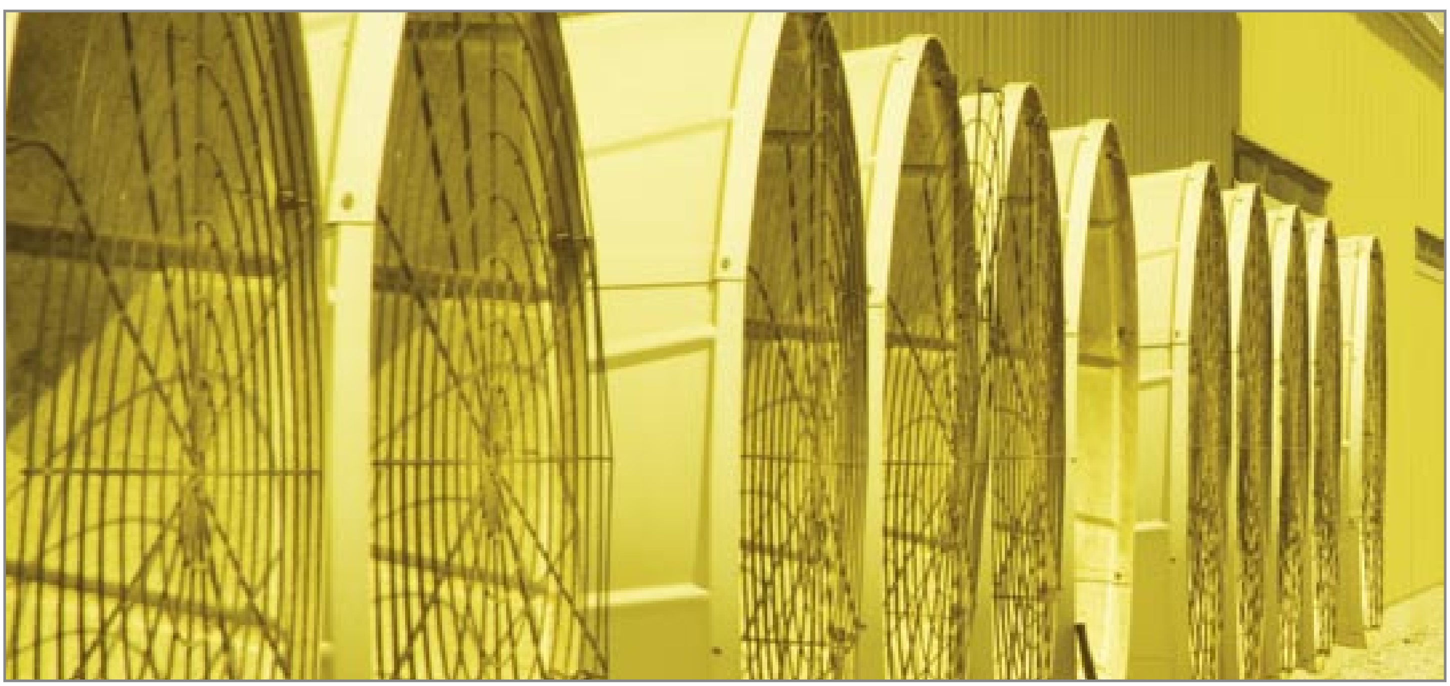
WINTER 2006-07

For Humanity, Through Discovery

If a research program for a college had a calling card, perhaps it might contain a line about why the students, faculty, and industrial partners are putting forth the **discovery** effort. At Purdue's College of Engineering, we believe all of our research endeavors are for the betterment of **humanity**. We're addressing the grand challenges that confront this generation and threaten the next. The list of challenges is familiar and in the headlines daily: energy, the environment, healthcare, and more.

Breakthroughs have to start somewhere. With this publication we're talking about where Purdue engineers are beginning to make headway. A novel collaboration could change how municipalities deliver clean drinking water to millions of people. Two new National Science Foundation-sponsored Engineering Research Centers will make important discoveries on the energy and healthcare front. A team of environmental engineers is helping set standards on air-quality issues. And we're taking a closer look at how globalization needs to be part of an engineering education.

The big problems may take years in the solving, but it's the undertaking that's important. With half a decade behind us in the 21st century, our researchers at Purdue remain ever mindful of and committed to work on the **engineering edge**.



Contents

2 Perspectives
4 Pathogen Detectives
12 Healthcare Package
20 Energy Innovations
30 Environmental Evaluations
38 Global Happenings
48 Future

Perspectives

Dr. Arden L. Bement, Jr.
Director, National Science Foundation
D. A. Ross Distinguished Professor
of Nuclear Engineering

My years at Purdue hold many good memories, but without doubt, the enthusiasm and commitment of the engineering students is the most vivid. These young people come to their studies believing, as generations of engineers have done, that they can and will accomplish something valuable for the nation and the world.

We count on them to hold steadfastly to this vision, melding principle and practice, as they move on to professional positions and make their unique contributions to society. The grand mission for universities is to provide them with the knowledge and skills they will need to realize their ambitions and dreams. Nothing less than the nation's future prosperity depends upon meeting this challenge successfully.

The accelerating pace of scientific discovery and technological change, fired by more robust computing and networking, is the locomotive driving the relentless pressure of global competition. The nations that are pulling ahead are those that quickly embrace new knowledge, regardless of its source, and that propel their citizens along new educational, economic, and technological pathways.

In this changing environment, we cannot afford to be complacent about our nation's ability to sustain its long history of leadership in science, engineering, and technology. Intellectual and human capital, infrastructure, and investment in research and development are the three fundamental requirements for survival in the new "knowledge economy." This is a lesson that nations like China and India are quickly learning, as they build powerful economic momentum through a burgeoning science and engineering workforce and research capacity.

Crafting an educational environment to keep pace and excel is an enormous challenge. As Director of the National Science Foundation, I abide by the Foundation's enduring precept that research and education are two sides of the same coin. Inviting students to be partners in exploring science and engineering frontiers is the best way to prepare the next generation of science and engineering talent, and should be proffered early and often. As they leave the university to enter the workforce, these freshly minted engineers carry with them the experience and know-how to be genuine leaders in innovation.

The flip side of the coin is a focus on transformational research. The Foundation's unique role within a broader U.S. research and development enterprise is to search out and support the most promising fundamental research at the frontiers of discovery. Dogging the frontier is imperative because revolutionary concepts are generally found in unexplored territory. This is the realm of transformational ideas that can spawn innovative technologies, solve major dilemmas that challenge our societies, and dramatically change our lives.

Purdue's engineering programs take a fresh approach to research and education. Discovery Park, with its many multidisciplinary centers, serves as a resource for industry, government, and the educational community at large. A focus on grand themes in energy, environment, disease, and education, puts a spotlight on important social goals in a world increasingly dependent on complex technologies to solve human quandaries. Both are significant responses to the changing research and education landscape, propelled by the accelerating pace of discovery and innovation, and shaped by the realities of globalization.

The ultimate purpose of the science and engineering enterprise is to put knowledge to work for the growth of the economy and the well-being of society. Education is the font from which every such vital transformation flows. We must continue to encourage our students to turn the familiar world upside down.

Leah H. Jamieson
John A. Edwardson Dean of Engineering and Ransburg Distinguished Professor of Electrical and Computer Engineering

I am pleased to present *Purdue's Engineering Edge*, the fifth installment of our research publication. In the College of Engineering, we have hundreds of faculty and students working on what we consider the ultimate cutting edge. These pages highlight the work of many people advancing areas of critical importance. In collaboration with government agencies and industry, our researchers are tackling the big problems: the quality of drinking water, healthcare, energy needs, the environment, as well as how to engineer solutions for a seemingly shrinking, faster-paced world. I invite you to discover for yourself how Purdue Engineering is addressing these challenges and opening new doors to discovery.

Jay Gore
Associate Dean, Office of Research and Entrepreneurship and Vincent. P. Reilly Professor of Mechanical Engineering

Purdue University is becoming quite a meeting place these days. From the fast-growing Discovery Park and all throughout campus our faculty members are branching out, collaborating not only with world-renowned experts outside of their own disciplines, but with industrial partners as well. Last year's *Purdue's Engineering Edge* focused on some of the biggest problems challenging humanity. This year we're highlighting some of the "small steps" our engineers are taking toward solving them. From patented technologies to a pair of new Engineering Research Centers to the discovery-based learning programs like our Summer Undergraduate Research Fellowships, Purdue continues to push its engineering edge further. This publication details a handful of the meeting minds, scientific breakthroughs, and goals that define our research success.

Pathogen
Detectives

Water Enlightenment

— WILLIAM MEINERS

When three very different Purdue researchers put their heads and labs together under the umbrella project of using UV radiation to treat drinking water, their collaboration became the breakthrough.

Research Triangle: Ernest "Chip" Blatchley (seated), shown here with colleagues J. Paul Robinson (bearded), a professor of both biomedical engineering and immunopharmacology, and Donald Bergstrom, a professor of medicinal chemistry and molecular pharmacology, is uncovering revolutionary ways to treat drinking water.

A nasty bug made its way through the Milwaukee drinking water supply in 1993. The offending microorganism, *Cryptosporidium*—a mouthful in name and a stomach-turner by nature—affected more than 400,000 residents in what is now recognized as the largest waterborne outbreak in U.S. history. A highly infectious threat, "Crypto," similar to the Giardia parasite, is harmful to anyone who ingests it and possibly deadly to those with previously weakened immune systems.

For environmental engineers, *Crypto* sounded an alarm for improved treatment systems, including the use of ultraviolet (UV) radiation to keep drinking water clean. Ernest "Chip" Blatchley III, a professor of civil engineering, works on that frontline battle. But because of perception problems associated with UV, the battle began uphill. "In the recent past," Blatchley says, "as late as the late 1990s, the perception in this country was that UV wasn't practical for drinking water applications because people had incorrect information about what it would actually do."

UV disinfection, it now seems, is right for the times. According to Blatchley, some fairly important discoveries in the late 1990s proved UV to be a very effective disinfectant against many microorganisms that threaten drinking water supplies. "There are a few exceptions," he says, "but it's a much broader antimicrobial agent than people previously believed."

UV is also energy- and cost-effective. "The UV process is very fast," Blatchley says, "so the reactors occupy only a small amount of space." It also turns out that UV doesn't use much power, addressing the misperception of a power-intensive process. And UV does little or nothing to change the chemistry of the water.

With these collective attributes, there's tremendous interest in the use of UV applications in drinking water production. Literally thousands of utilities in the United States are considering it, Blatchley says, including New York City, which provides the largest drinking water supply in the country, treating up to 2.5 billion gallons of water every day.

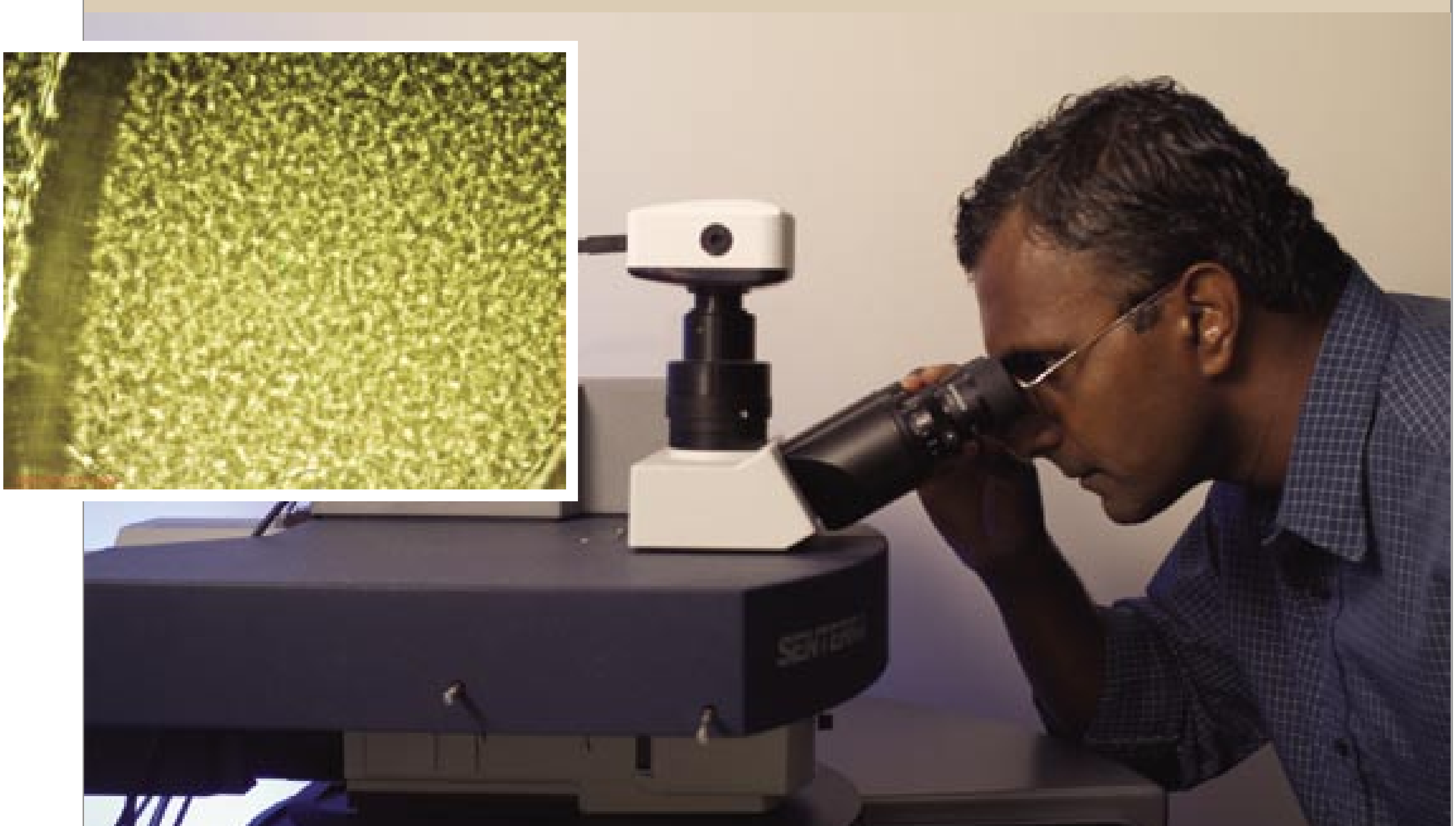
Singular Minded

How one researcher is pursuing pathogens down to their very single-cell existence.

In the food pathogen detection business, the focus is becoming sharper and sharper these days. How sensitive, how specific can researchers fine-tune their methods to identify trace amounts of *E. coli*, *Salmonella sp.*, *Listeria sp.*, or *Yersinia* and other dangerous organisms that lurk beneath what we eat and drink?

Joseph Irudayaraj, an associate professor of agricultural and biological engineering, would like the bad stuff to reveal itself from a single cell. And that type of success could eliminate a whole lot of bad apples.

Involved in pathogen research for about a decade, Irudayaraj and his group are focusing on the development of biosensors, nanotools, and



Zeroing In: Joseph Irudayaraj, an associate professor of agricultural and biological engineering, is trying to detect food pathogens down to the single cell. (Inset): The oocyte cell (pictured), which is not a pathogen, is used for calibration purposes. Irudayaraj says, "By examining single-particle SERS effects in big cells such as oocyte, we can refine our methods for smaller pathogenic organisms."

single-molecule methods relevant to the detection, diagnosis, and prognosis of diseases. The single molecule focus, he says, is at the heart of his teaching and research efforts, which take place in both Bindley Biosciences and the Birck Nanotechnology Center, as well as in the Department of Agricultural and Biological Engineering and in Food Sciences.

"With the current state of technology available via spectroscopy, microscopy, and other optical methods, I think the incorporation of nanotools could push the limit to where we need to be," he says. "With a lot of the commercial systems we can detect up to 1,000 cells per milliliter. Clearly, this is not sufficient because we want to detect one pathogen." Irudayaraj adds, "I believe we are on the way to accomplishing this." A similar method is also being developed to detect cancer cell surface biomarkers in his lab.

So how do they get to that next level? "We are using nanostructures of varying sizes, say 40-100 nanometers, and shapes [such as rods, prisms, and bows] to lock onto nanometer scale cell surface markers on cell surfaces," he says. "We call it single-particle sensitivity, which allows us to monitor a single interaction at nanoscale sensitivity."

A parallel technique combining biosensor strategies and spectroscopy has also been developed in collaboration with scientists from food science, material science, and electrical and computer engineering. "An interesting concept," says Irudayaraj, who authored an article on the subject in *Analytical Chemistry* this year, "because spectroscopy allows the elucidation of molecular fingerprints and biosensors tells us how things interact. That's a powerful way of combining different sensing technologies."

Through a collaborative project with a membrane chemistry group in Israel, Irudayaraj and colleagues are also using polymer sensor films to monitor interactions. "It's a simple way of detection," he says. "We can make these films, put them on the surface of an apple or a package, and, depending on the bacteria and type of interactions, the film may change color."

Irudayaraj predicts breakthroughs in sensor technologies that will impact food packaging and other sectors where security is quite likely to be compromised. "Any sort of compromise to a food package will have an effect on food quality and safety," he says. "A sensor that can be attached to a package to relay information about the quality or safety attributes via some sort of audio or visual response is very possible in the near future."

By combining the tools of nanotechnology with the synergism of collaborations on Purdue's campus and beyond, Irudayaraj remains on the prowl for a single-cell nemesis.

●●● —**W.M.**

The ability of a UV system to disinfect depends on the "dose" of UV delivered to the microorganisms in the water. In practical UV systems, however, microorganisms each follow a unique path through the reactor. As a result, they each receive different doses. So real UV reactors deliver a distribution of UV doses, and it is that dose distribution that determines the effectiveness of the reactor.

Until recently, techniques did not exist to actually measure the dose distribution delivered by a UV system. Instead, the standard practice was to measure the ability of a UV system to "kill" a standardized microorganism. This method, known as "biodosimetry," provided a rough indication of the performance of the system, but it gave no information about the dose distribution.

In collaboration with several other researchers at Purdue and, after some seven years of intensive research, the Blatchley group recently developed a method whereby dose distribution measurements can be collected on UV systems.

Collaborating Across Campus

Success within the scientific process often comes from fortuitous circumstances. For Blatchley, it followed a unique cross-disciplinary collaboration. Biodosimetry had for years been the standard (and only) method for the measurement of UV reactor performance. But the expensive test provides only limited information about the system. Researchers needed a better method for a characterization of performance in UV systems.

To address this need, dyed microspheres were developed. They mimic the behavior of individual microorganisms, but the dye chosen for this application makes it possible to measure the UV dose delivered to each microsphere. "With the analytical tools we have access to, we can measure the dose of UV radiation delivered to each microsphere in a large population," Blatchley says. Not something that can currently be done with microorganisms.

The microsphere system allows making quantitative, accurate statements about the distribution of doses that are delivered by a UV reactor, big or small. In turn, that information allows researchers to make quantitative statements about how the system will work.

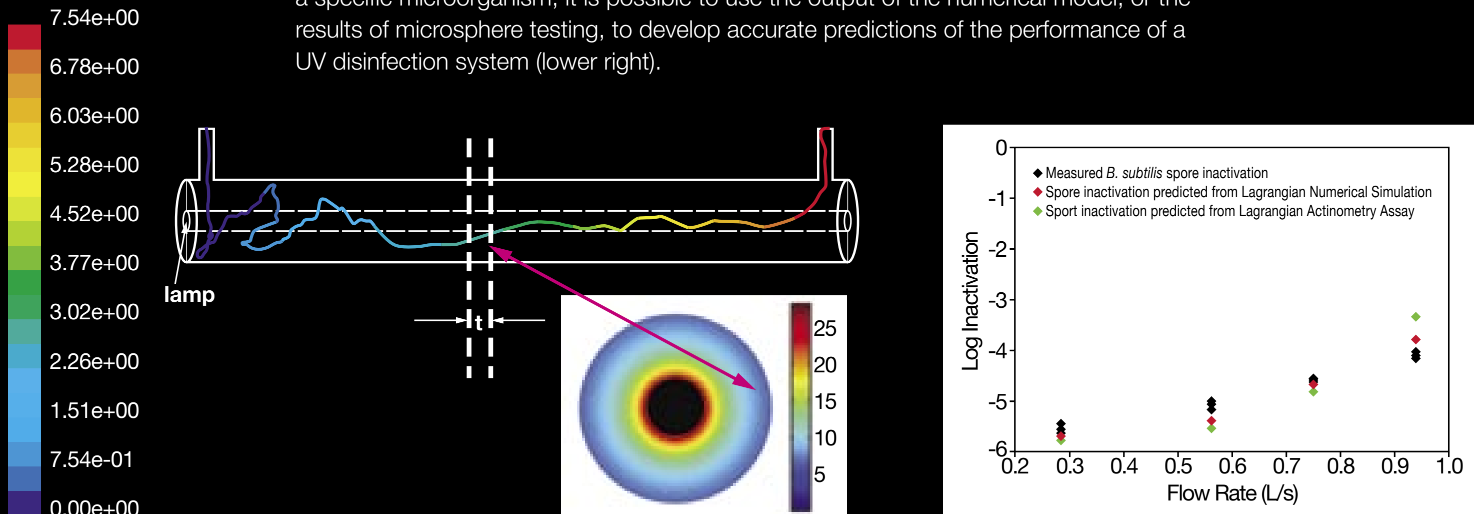
To be successful, Blatchley needed some help from across campus. That's where Donald Bergstrom and J. Paul Robinson came in. Bergstrom, a professor of medicinal chemistry and molecular pharmacology, has worked for many years in the area of nucleic acid photochemistry. He designed and built the microspheres. "Chip came to us with specifications," Bergstrom says. "He needed a microsphere that could mimic bacteria in size and behavior in solution."

The microspheres also needed to be sensitive to UV light in a way that dosage of accumulated UV could actually be measured as the synthetic particles move through the water system. "We happened to have a molecule on the shelf that we discovered in the late 1970s that had the same properties required for the system," Bergstrom says.

The molecule undergoes a measurable chemical change when it is exposed to UV radiation. Measurable, Bergstrom says, because the molecule is nonfluorescent before exposure to the UV radiation and fluorescent after it. Because a great many of these molecules can be attached to each microsphere, the fluorescence signal from each microsphere can be related to the UV dose it receives.

Robinson helped take quantification to new heights. The director of Purdue's cytometry laboratories and a professor of both biomedical engineering and immunopharmacology, Robinson also took off-the-shelf technology and applied it to the

Numerical simulations of the radiation intensity field can be used to predict dose delivery to individual particles (lower left). When combined with UV dose-response behavior for a specific microorganism, it is possible to use the output of the numerical model, or the results of microsphere testing, to develop accurate predictions of the performance of a UV disinfection system (lower right).



UV Success: The microsphere system allows researchers to make quantitative, accurate statements about distribution doses delivered by UV reactors.

drinking water project. "We have some very sophisticated technologies that were developed primarily for the clinical diagnostic world," he says. "These technologies use lasers to analyze particles. So we shoot the particles with a laser beam and collect many parameters."

They can shoot and analyze on the order of thousands of particles per second, resulting in some complex multivariate analyses. "It's exciting to use existing detection technologies and then identify the specific needs for a completely different community," Robinson says.

For the research trio, the application of the three-system approach is most exciting. "It's the right combination rather than the breakthrough," says Bergstrom. "The collaboration among three different investigators doing different parts all created the breakthrough." Within their own corners on campus, a project involving a chemistry system, a UV reactor system, and a detection system all came together.

An Industry Splash

Robinson foresees the technology leading to the development of relatively inexpensive equipment—in the $10,000 to $20,000 range—that water companies will find necessary.

The progress includes work in conjunction with HydroQual, a New Jersey-based environmental company that has for more than 35 years used mathematical models to address the concerns of pollutant discharges on water quality and ecosystem health.

Photo Courtesy of HydroQual

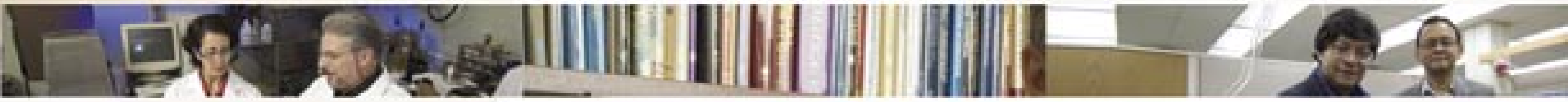
Above HydroQual: The campus breakthrough has led to an industry collaboration. HydroQual, a New Jersey-based environmental company, conceived, designed, and is operating the UV Validation and Research Center of New York, in Johnstown, New York. The company is also hoping to apply the microspheres at very large scales.

"We've been working with the people at HydroQual to apply these microspheres at very large scales at flow rates of up to 60 million gallons per day," says Blatchley. "That would be the largest UV reactor ever developed, and it's what New York City would need to do if they have about 50 of these things working in parallel to treat 2.5 billion gallons of water a day."

And the parties in that collaboration also seem to be getting along swimmingly. "We've followed Chip's work for many years," says Karl Scheible, a principal at HydroQual. "He has been innovative and in the forefront in defining and researching key issues regarding the proper design and application of UV."

With patents in the works and interested water utilities ranging from New York to California wanting to learn more, there's seemingly no rest for these water-weary researchers at Purdue. But as the cross-campus collaborations continue to spawn healthy breakthroughs, the three professors might each raise a glass of some sparkling tap to toast their present-day success. ●●●

Healthcare
Package

Tiny Pieces, Big Picture

—GINA P. VOZENILEK

Purdue researchers work to advance a new and needed fundamental science of solids.

To understand just what's going on in the new Engineering Research Center (ERC) for Structured Organic Composites (SOC), try starting with a definition of that term. You'll get no help from a dictionary or a Google search; SOC is simply too new.

You'll need to talk with Gintaras "Rex" Reklaitis, the Purdue Edward W. Comings Professor of Chemical Engineering and deputy director for the multiuniversity ERC. He explains reductively: "An SOC is a material that consists of powdered solids of different types that are somehow 'glued' together," like a tablet, a capsule, or a granular matrix. Pharmaceutical applications come to mind first—all the many forms of tablets shaking around in plastic tubes in your medicine chest, for example—but the time-release fertilizer you sprinkle on your lawn to grow a lush green carpet or the "flavor-blasted" snack chips you pop into your mouth are SOCs, too. Who knew? "You probably won't find SOC on the Web yet," Reklaitis says. "We just coined that term."

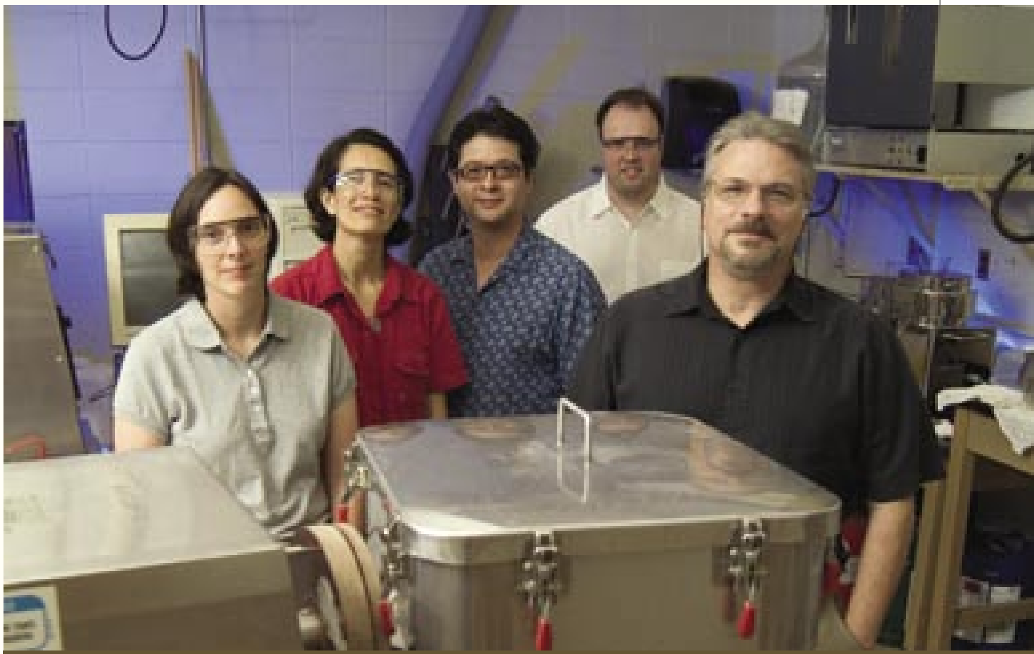
Solid New Thinking

This need for a new lingo bespeaks a need for a new science. In fact, the National Science Foundation believes so strongly in the importance of this work that it has awarded the ERC for SOC a five-year, $15 million grant to push the frontiers of this science forward.

The ERC includes four universities: Purdue, the New Jersey Institute of Technology (NJIT), the University of Puerto Rico, and Rutgers, which will take the lead under the direction of Fernando Muzzio, a chemical engineering professor. Scientists from these schools will move toward enhancing the quality and consistency of solid-dosage form pharmaceuticals, processed foods, agrichemicals, and other products that consist of SOCs. Industry partners, such as Eli Lilly, Pfizer, GlaxoSmithKline, Abbott, PepsiCo/Quaker, and Procter & Gamble, will also lend their support to the ERC. The task of the ERC is to study organic solids and discover what really makes them

SOC Talk: Gintaras "Rex" Reklaitis, the Purdue Edward W. Comings Professor of Chemical Engineering and deputy director for the new multiuniversity Engineering Research Center for Structured Organic Composites (SOC), explains what an SOC is. He says, "An SOC is a material that consists of powdered solids of different types that are somehow 'glued' together."

tick, or in some cases, stick. "Our problem is a fundamental lack of understanding of the characteristics of an SOC," explains Ken Morris, a professor of industrial and physical pharmacy. "Most of our knowledge is empirically derived. But as molecules become more and more complicated, we can't really rely on trial and error because it's not efficient and because some problems won't yield to a trial-and-error approach," Morris says. "We need to be able to anticipate how a molecular solid will behave."



Pharmacy Lineup: The pharmacy collaboration with engineering is critical to the new Engineering Research Center's success. Already at Purdue, interested undergrads can complete a minor concentration in pharmaceutical engineering. Folks here from the industrial and physical pharmacy program include (left to right) assistant professors Lynne Taylor, Teresa Carvajal, and Rodolfo Pinal; Stephan Boerrigter, a visiting assistant professor; and Ken Morris, a professor and associate head of the department.

Model for the Future

Computer animation and mathematical modeling will help researchers build "virtual" materials and test how they will work before being manufactured. Other industries' manufacturing practices provide useful examples. "The Boeing 777 was fully designed by computers. They didn't build two dozen models and try them out," Reklaitis points out. "Only when the 777 was all put together in computer models did they build and test it."

Designing and employing predictive models will ultimately increase efficiency in manufacturing SOCs in large quantities. "This could lead to a significant reduction in the cost of manufacturing pharmaceutical, nutritional, and agricultural products, and that will help meet the needs of society," notes Reklaitis.

"One of the most expensive parts of developing a drug is the experimentation," concurs Prabir Basu, executive director of NIPTE (see sidebar). "If we had predictive knowledge, we could conduct fewer, targeted experiments, but that science is not yet available."

Basu acknowledges that researchers can predict how gases will behave, but the properties of SOCs are more elusive. He points out that a 1-gram tablet may contain a mere 20 mg of active ingredient. The rest is filler and additives, called "excipients," which are needed to deliver the active ingredient in a stable, usable form. Some excipients may be used to "glue" the whole tablet together, some may help it dissolve, and some may coat the tablet to prevent it from swelling with ambient moisture.

"Not much is understood about the properties of these fillers," says Basu. "There are batch-to-batch variations in these excipients, and how they will affect the final product is unknown." Some excipients, such as starch, are organic molecules and can even exhibit seasonal variations. In the push to construct the predictive models of SOCs, the study of these excipients will make up a big piece of the puzzle.

Next-Generation Educators

As the knowledge base of SOCs expands, a need is emerging to develop a unified curriculum for degrees in pharmaceutical engineering, one of the most obvious and important benefits of the new research. Currently only a handful of formalized study programs in pharmaceutical engineering exist (the two oldest being at Rutgers and NJIT). At Purdue, interested undergrads can already now complete a minor concentration in pharmaceutical engineering, but that is a rare opportunity. "Part of the ERC goal is to reconcile requirements for the PhD in pharmaceutical engineering across the nation," says Morris. "We need to populate positions in academia and industry. The industry will need thousands of them, and the universities will need professors to teach the next generation."

A long-term educational investment strategy is in play, too. The ERC for SOC is casting a wide net to catch talented minds and haul them into the ranks of tomorrow's pharmaceutical engineers. "It's a pretty elaborate plan," Morris says, describing a program that will attract young thinkers to science as early as grade school. Purdue researchers will provide direct outreach to high school students by offering summer internships for work with ERC researchers. Even younger students will benefit indirectly from their teachers who visit the labs at Purdue "to explore ways to remove student fears of tackling technical subjects," says Morris. Hand in hand with the aim of recruiting young minds to science and ultimately into pharmaceutical engineering is another of the ERC's stated goals: To establish effective mechanisms for the inclusion and participation of minorities and women at all levels.

"We need to keep America competitive at large," Morris insists, "and you can't really have the opportunity to cross-fertilize ideas if you don't have diversity. If you look at science disciplines, they grow by taking things outside their area, as chemistry uses physics and biology draws from chemistry. The analogy to diversity is the same."

If diversity is an agent of ingenuity, then the interdisciplinary composition of the ERC itself, which draws on the varied expertise and experiences of pharmaceutical scientists, chemical engineers, mechanical engineers, material science engineers, industrial engineers, chemists, and informaticians, is a brilliant new plan. ●●●

Beyond the Mortar and Pestle

By modernizing the methods of pharmaceutical manufacturing, researchers from the College of Engineering and the School of Pharmacy and Pharmaceutical Sciences are hoping to increase the speed of drug delivery.

The cost is staggering. In 2004, the Food and Drug Administration estimated a $1.7 billion price tag for bringing a new drug to market. In 2006 that number now looks more like $2.0-$2.5 billion, according to Prabir Basu, executive director of the National Institute for Pharmaceutical Technology and Education (NIPTE). "Everyone is concerned about the cost of drugs, but no amount of beating up on industry or screaming politicians can fix the problem. We need science."

Shot in the Arm

This pressing need is gaining attention. Senator Richard Lugar, R-Ind., has introduced a bill in the Senate that would give a boost to NIPTE, the Purdue-led consortium created to develop pharmaceutical products faster, more safely, and at lower cost.

The Pharmaceutical Technology and Education Act would establish a partnership among the Food and Drug Administration and other federal agencies, the pharmaceutical and medical industries, and the Purdue-led 11-member NIPTE consortium. Basu is pleased with the support. "This legislation is significant because it establishes funding that will go a long way toward developing this neglected area," he says.

Basu wants engineers to get involved in moving pharmaceutical manufacturing technology forward. "Once a new therapy is discovered, product development and manufacturing will remain the same as they have for decades," says Basu. "The technology is primitive compared to that available to discover new drugs. Our institute will spend its time doing research in an effort to make the drug development and manufacturing processes more modern, resulting in more efficient and predictable drug performance."

Umbrella Project: Prabir Basu, the executive director of the National Institute for Pharmaceutical Technology and Education (NIPTE), knows a collaborative scientific effort will help speed drug delivery. Furthermore, a proposed Pharmaceutical Technology and Education Act would establish a partnership among the Food and Drug Administration, the pharmaceutical and medical industries, and the Purdue-led 11-member NIPTE consortium.

Highway Man: Venkat Venkatasubramanian, a professor of chemical engineering, is fond of a highway analogy to describe the informatics that will shuttle all the data associated with a 12-year "product pipeline" from discovery to delivery. "Right now all we have is a country dirt road full of potholes," he says. He's hoping computers will help pave a superhighway leading to quicker pharmaceutical deliveries.

Building an Informatics Superhighway

As a single drug travels through the laborious 12-year "product pipeline" from discovery to delivery, it creates a dizzying trail of data. Over the years, a multitude of researchers come and go, and they all amass notebooks, printouts, electronic files, spreadsheets, and reports to record tons of information: raw data, observations, mathematical models, equations, and correlations. Ken Morris, a professor of industrial pharmacy and researcher for the new ERC (see story), notes that just looking for files of data consumes on average roughly 25 percent of researchers' time. "It's a horrendous information-gathering chore," complains fellow ERC researcher Gintaras "Rex" Reklaitis, the Purdue Edward W. Comings Professor of Chemical Engineering.

That's because the informatics superhighway to shuttle all those data and models hasn't been built yet. "Right now all we have is a country dirt road full of potholes," says Venkat Venkatasubramanian, a professor of chemical engineering. This diverse collection of information from a wide array of people and sources needs to be organized, integrated, and utilized for real-time optimal decision making. He says scientists like Morris and Reklaitis are "building Ferraris to accelerate us from ignorance to understanding," and he sees it as his job to develop a comprehensive informatics infrastructure to pave their way.

Pharmacy of the Future

Improving the science and systems of manufacturing pharmaceuticals has the obvious, important goal of speeding development and thus reducing costs. Manufacturing innovations will therefore also encourage industry to pursue the development of a greater variety of drugs and not just "blockbuster" medicines; shortened development time means greater affordability for making "niche" drugs and Third World medicines.

Other advancements are on the horizon. Morris talks about a whole pharmaceutical factory the size of an ink-jet printer. For some types of drugs, this technology would allow patients to have their prescriptions customized to their body mass. Morris speculates that these machines could someday be found at local drugstores and even taken out to the battlefield.

"We are all aging one day at a time, and sooner or later we can expect to need medicine," notes Venkatasubramanian. "My team and I are working on a problem that can help society at large." ●●● —**G.V.**

A Medical Meeting of the Minds

The interdisciplinary Regenstrief Center for Healthcare Engineering seeks out novel solutions for healthcare quandaries.

Engineering Healthcare: Joseph Pekny, the founding director of the Regenstrief Center for Healthcare Engineering and a professor of chemical engineering, stands in Purdue's burgeoning Discovery Park, where he hopes a collaborative effort will help revolutionize healthcare in this country and beyond.

Shortening wait times in the emergency room, streamlining patient charts with electronic record-keeping, overcoming language barriers between patients and doctors, facilitating healthcare delivery in poor countries. A host of challenges faces healthcare providers, and now the Regenstrief Center for Healthcare Engineering (RCHE) at Purdue is joining the effort to solve them. The RCHE was funded by its namesake foundation in 2005, specifically, "to catalyze improvements in the healthcare delivery system through the discovery, learning, and engagement of engineering, science, technology, and management principles," explains founding director Joseph Pekny.

To accomplish its mission, RCHE draws from an unusually synergistic matrix of talent. All 13 colleges of Purdue, from engineering to liberal arts, have a hand in the new center. Pekny, a professor of chemical engineering, characterizes the interdisciplinary nature of the RCHE as "exhilarating."

Steven Witz, RCHE's director, looks ahead to an "ever-broadening scope of opportunity for faculty involvement in RCHE." A database of ongoing projects and faculty contributors accumulates a record of special skills and experience that can be drawn from when a new problem or project emerges.

Local Solutions

Interdisciplinary innovation is at the heart of RCHE's Healthcare Technical Assistance Program (HTAP), which invites hospitals to approach them for specific technical help. Then the RCHE assembles a customized, cross-collegial team of experts to study the problem and devise solutions.

One HTAP client is Dunn Memorial Hospital, in Bedford, Indiana, where an RCHE team was dispatched to analyze patient flow, security, and physical layout issues in the Emergency Department.

By helping the community, RCHE team members gain valuable insights. Says Pekny, "HTAP allows our researchers to sample real problems in the field. We use this sampling as a strategic tool to better focus our research." And HTAP affords interested faculty direct exposure to the healthcare arena, where they can essentially "learn the language and culture of the healthcare industry," adds Witz. This helps researchers to better understand how to help.

When an idea has been highly successful, HTAP likes trying to replicate a project and to implement its research in other settings. "Which characteristics and measures are most influential? Most beneficial?" wonders Witz, who hopes that by testing a solution broadly, HTAP can identify general principles. Together with the Indiana Hospital and Health Association, HTAP is interested in developing a compendium of "best practices" to be applied statewide.

Beyond Our Backyard

Through the RCHE, Mark Lawley and Yuehwern Yih are building a nutritional supply chain to help fight AIDS in Africa. They say that without proper nutrition, the drugs used to treat AIDS patients won't work. They are collaborating with the Indiana University-Kenya Partnership and retired physician Dr. Joe Mamlin, who runs a dozen AIDS clinics treating 400 patients a month around Eldoret in western Kenya.

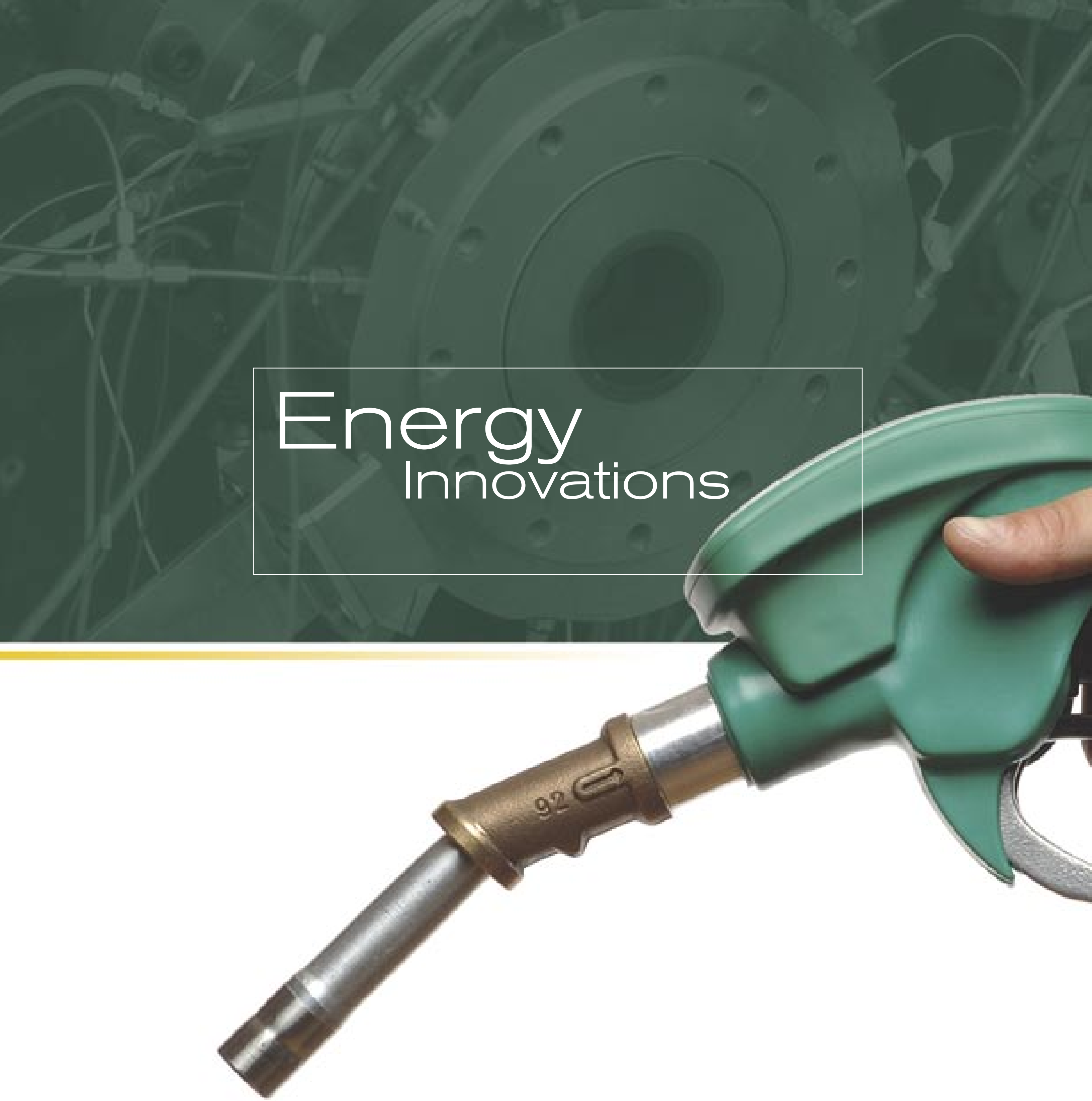
The program was receiving 19 metric tons of dry food, such as corn, beans, and soybean powder, each month from the World Food Program to feed 2,200 people. Every day the farms produce 800 eggs and 450 packets of milk product, each containing 500 milliliters.

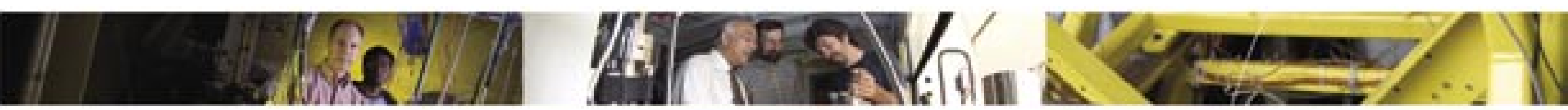
Relief Systems: Purdue industrial engineers Mark Lawley (left) and Yuehwern Yih (right) donate materials to the schoolmaster at the Besiebor Primary School in Turbo, Kenya. Lawley and Yih, faculty fellows at Purdue's Regenstrief Center for Healthcare Engineering, are putting together a system for food delivery to a dozen AIDS clinics in Kenya. The pair made two trips to Kenya to understand the components and complexities of delivering the nutrition necessary so that antiretroviral drugs will work on the patients. (Photograph courtesy of Yih).

Lawley, an associate professor of industrial engineering, says there are many variables to evaluate, to account for, and to ultimately coordinate: farm crops and production, yield, and perishability; the dry goods packing center operation and its weighing, packaging, and tracking operations; the condition, reliability, and mileage of delivery vehicles and how they are maintained; the generally bad road conditions; and the distribution centers, supply chain, and scheduling.

"We will eventually link the food distribution database with the patient medical record system so that nutritional researchers can study the effects of nutrition on AIDS treatment," Yih says. "To our knowledge, no one has done this before." ●●●
—G.V.

Energy Innovations





Energy Recovery

—LINDA THOMAS TERHUNE

The new Purdue Energy Research Center for Compact and Efficient Fluid Power will focus on energy-saving technologies.

Fluid power is at the heart of many machines that fly, push, spin, and move loads. Its applications are as familiar as a hydraulic lift for changing car tires and as obscure as a baseball-sized actuator that controls ailerons on huge jetliners. Yet despite the vital role fluid power plays in mechanics, it is an underdog in the world of engineering. Purdue's new Engineering Research Center (ERC) for Compact and Efficient Fluid Power could change that.

Fluid power, which encompasses hydraulics and pneumatics, is a $33 billion industry worldwide—$12 billion in the U.S. alone. It is used in aerospace, agriculture, construction, offshore, manufacturing, mining, and transportation.

In Europe, which has a history of high gas prices, researchers have long focused on the cost-saving benefits of fluid power. But in the United States, research of this kind reached its acme in the late 1950s and 1960s and hasn't been the focus of much attention by engineering schools since the 1970s.

Favoring Fluidity

Monika Ivantysynova, the Purdue MAHA Professor of Fluid Power Systems and a professor of mechanical engineering and agricultural and biological engineering, is on a mission to spread the word about the efficiency and economy of fluid power. Ivantysynova is head of the new Purdue ERC. She quickly lists the advantages of fluid power: It is more powerful and compact and lighter than traditional electromechanical systems. A fluid power system on a windmill, for example, would be the

Fluid Investigators: Monika Ivantysynova (center), the Purdue MAHA Professor of Fluid Power Systems and a professor of both mechanical and agricultural and biological engineering, is spreading the word about the efficiency and economy of fluid power. Shown here with Edat Kaya (left), a lab engineer, and Donnell Cunningham, a student from the Summer Undergraduate Research Program, Ivantysynova, the head of the Engineering Research Center for Compact and Efficient Fluid Power, is at work in the MAHA Fluid Power Center.

size of a coffee mug; an electrical power unit would be about the size of a trash can.

Fluid power also offers the potential for energy recovery, which can result in large savings on fuel costs, estimated in the transportation sector alone to reach into the area of 100 million barrels of oil. In the automobile industry, a 10 percent improvement in efficiency in passenger car energy could save about $100 billion a year, according to Ivantysynova, who predicts that a hydraulic hybrid car will be on the market in less than 10 years.

NSF Sponsored

The goal of the ERC is to make fluid power systems even more compact and efficient than they already are, with possible results not only saving millions of dollars, but also helping to save lives. The ERC, which was announced in May 2006, is funded by a $21 million five-year grant from the National Science Foundation (NSF). The center is actually a research network spread among five universities and based at the University of Minnesota, Twin Cities; Purdue houses one of the research laboratories in its MAHA Fluid Power Laboratory. Researchers at the University of Illinois, the Georgia Institute of Technology, and Vanderbilt University are also involved in the program. More than 50 industry partners will contribute an additional $3 million to the program. ERC scientists will focus on three areas: fluid power efficiency; compactness; and noise, vibration, leakage, and human factors. They will study ways to use fluid power more efficiently in off-road and on-road vehicles and in manufacturing. They will also explore applications that could spawn entirely new industries, such as hydraulic hybrid passenger cars and rescue and surgery robots, whose movements are not constrained by cables tying them to a power source.

"This center will advance fundamental knowledge, providing a platform for technology that will spawn new industries. We are impressed with the ambitious goals of the center for research and education and its strong partnership with industry," says Lynn Preston, leader of the Engineering Research Centers Program at NSF.

A native of Polenz, Germany, Ivantysynova began her career in industry, where she worked on pump design before moving to the aerospace industry in the early 1990s and developing electrohydrostatic flight control actuators for the Airbus A380. She moved to Purdue in 2004 from the Technical University of Hamburg in Germany, and brought her European laboratory with her as the foundation for the MAHA Fluid Power Research Center. Her current work focuses on energy-saving hydraulic drive systems and the development and optimization of pumps and motors. She estimates that a new generation of pumps, motors, and throttleless actuators will reduce energy consumption by up to 30 percent.

Educational Outgrowth

Besides her research efforts, Ivantysynova is also ardently dedicated to educating engineers and industry about her field. The lack of U.S. fluid power centers is a problem, she says, not only in terms of the nation's technological competitiveness—especially in the area of defense equipment—but also for engineering education. "Research centers do research, and they educate students, which strengthens the field. That is missing in the field of fluid in the U.S., but we will change this with the ERC," she says.

Ivantysynova's ambitious goals are to see that fluid power is taught in every mechanical engineering school in the United States and that Purdue becomes the world leader in the discipline. She currently has four doctoral students and eight master's students. In spring 2006, she introduced undergraduates to fluid power when she supervised a "Senior Capstone" course. The team's project involved principles of hydrostatic transmission and suspension in vehicle design.

Ivantysynova's advocacy work spreads well beyond Purdue. As a member of the scientific board of Fluid Power Net International (FPNI), the first virtual network in fluid power, her goal was to establish a special forum for young researchers. This occurred with the organization's first PhD symposium, which took place in Hamburg in 2000 and drew 150 students from five continents. The fourth FPNI PhD Symposium was held in Sarasota, Florida, in June 2006; Purdue students were among the presenters from 18 countries.The symposium is an integral part of ensuring the future of fluid power engineering, according to Robert Koski, founder and president of Sun Hydraulics, a Florida-based designer and manufacturer of high-performance screw-in hydraulic cartridge valves and manifolds.

"In the future there will be more collaborative research around the world, made possible by the Internet and the ability to transmit drawings and to have live demonstrations. Researchers have got to meet each other, know each other, know areas of expertise, and know what their resources are. Monika has been a tremendous push in that direction," says Koski, who has known Ivantysynova for a decade.

Under Ivantysynova's careful watch, the new ERC will do its part to foster improved fluid power education. Besides its research responsibilities, the center is also charged with developing youth education programs, improving efforts to increase student diversity in engineering, designing internship and exchange programs for undergraduate and graduate students, and offering short courses and labs for industry workers. "In my view, Monika is a step-function increase for research capabilities in North America. She has made a big difference, and the ERC is a good example of that. Research in North America has lagged behind, but now its quality is going to change," Koski says. ●●●

Hurrying Hydrogen

To find viable substitutes for fossil fuels, Purdue researchers are picking up the pace on hydrogen research.

Hydrogen is the subject of intensifying focus in the United States. As a fuel, it is unlike fossil fuels and releases virtually no pollutants. And it has the official seal of approval from President George W. Bush, whose $1.2 billion hydrogen fuel initiative is designed to reverse the nation's growing dependence on foreign oil.

Scientists and engineers at Purdue are among those working to improve hydrogen production, storage, and delivery. The studies range from the development of a tiny fuel cell that can power consumer items such as laptops, cell phones, and military field equipment, to new ways of generating and storing hydrogen. Their research was featured at the Hydrogen Initiative Symposium held at Purdue in April 2006. The event drew researchers and policy makers from around the world to discuss topics ranging from nanotechnology to environmental sciences and societal impacts; a second symposium will take place in April 2007.

At Zucrow Laboratories, tucked near the end of the Purdue airport runway, collaborative work is under way on hydrogen storage systems that will deliver energy for many uses in the future hydrogen economy, including cars, home heating, and portable electronic devices.

Research scientist Tim Pourpoint (PhD AAE '05) is leading a team of engineers from the School of Aeronautics and Astronautics that is developing test facilities. Highly pressurized hydrogen will be used there to conduct research on rockets that will travel to the moon at speeds greater than 20,000 miles per hour and on cars traveling up to 300 miles on a single tank of fuel.

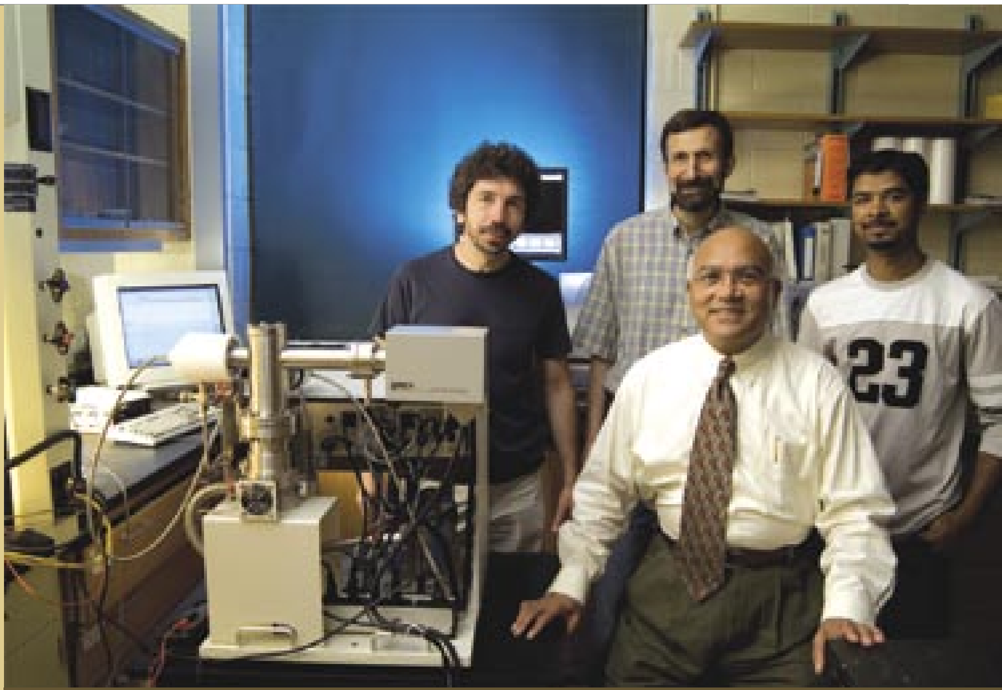
Pourpoint's work focuses on metal hydride-based hydrogen storage—hydrogen in gas form is flowed into a high-pressure tank containing a metal hydride powder that undergoes a transformation, leading to a very effective storage medium. The auto industry is interested because this research could develop ways of storing large quantities of hydrogen in small volumes, which is essential for automobile fuel tanks. The aerospace applications of Pourpoint's work involve hydrogen flow rates that are intense enough to power rockets.

While Pourpoint and his team look to power big machines, Arvind Varma, the R. Games Slayter Distinguished Professor and Head in the School of Chemical Engineering, is developing ways to use hydrogen to charge items as small as cell phones. His group has developed a triple borohydride-metal-water mixture that produces the hydrogen necessary to serve as a power source for portable fuel cells.

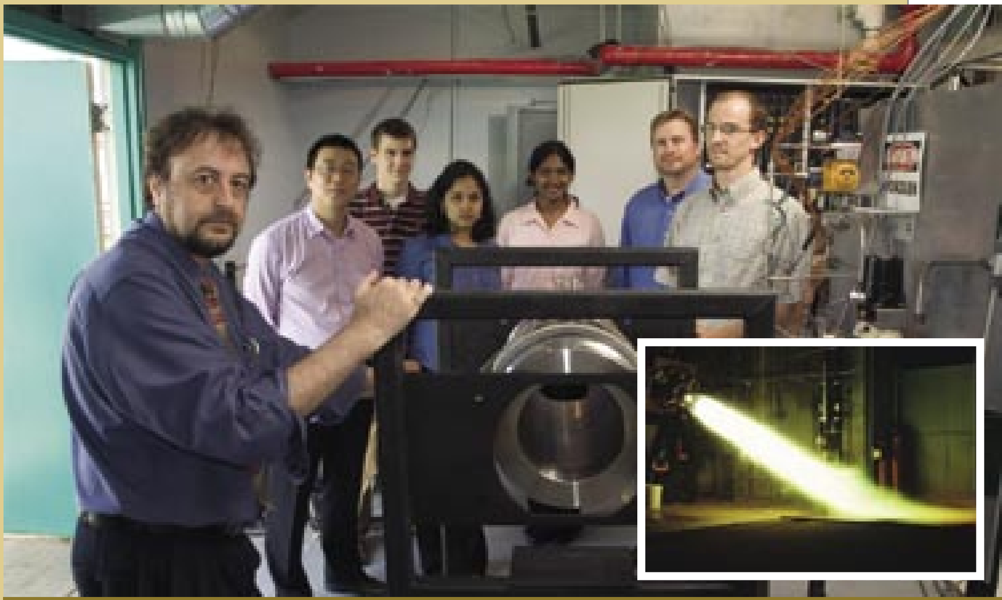
The envisioned portable device will contain hydrogen-storing pellets, an ignition system, and a microprocessor. When a battery indicates a low charge, the microprocessor will signal the combustion of a pellet, generating hydrogen to recharge the fuel cell and the battery. This method can provide eight times the energy density of the methanol-based fuel cell, resulting in a much lighter and powerful unit.

Varma's project, now in a vigorous research and prototype design stage, may find its first application in military uses. Pourpoint predicts that hydrogen's commercial use in the auto industry is about a decade away.

"It's satisfying to use creative scientific thinking in a relatively short time frame to develop a product that could be used in many applications to benefit society," Varma says. Pourpoint, whose research has thus far focused on rocket work, enjoys working on automotive applications through the metal hydride tank project. The work is more widely understood by the layperson, and it promises to help the environment. "The benefit of hydrogen is that it generates power that doesn't depend on something with a limited supply, such as fossil fuels," he says. And that's a winning proposition for all global citizens. ●●● —**L.T.T.**



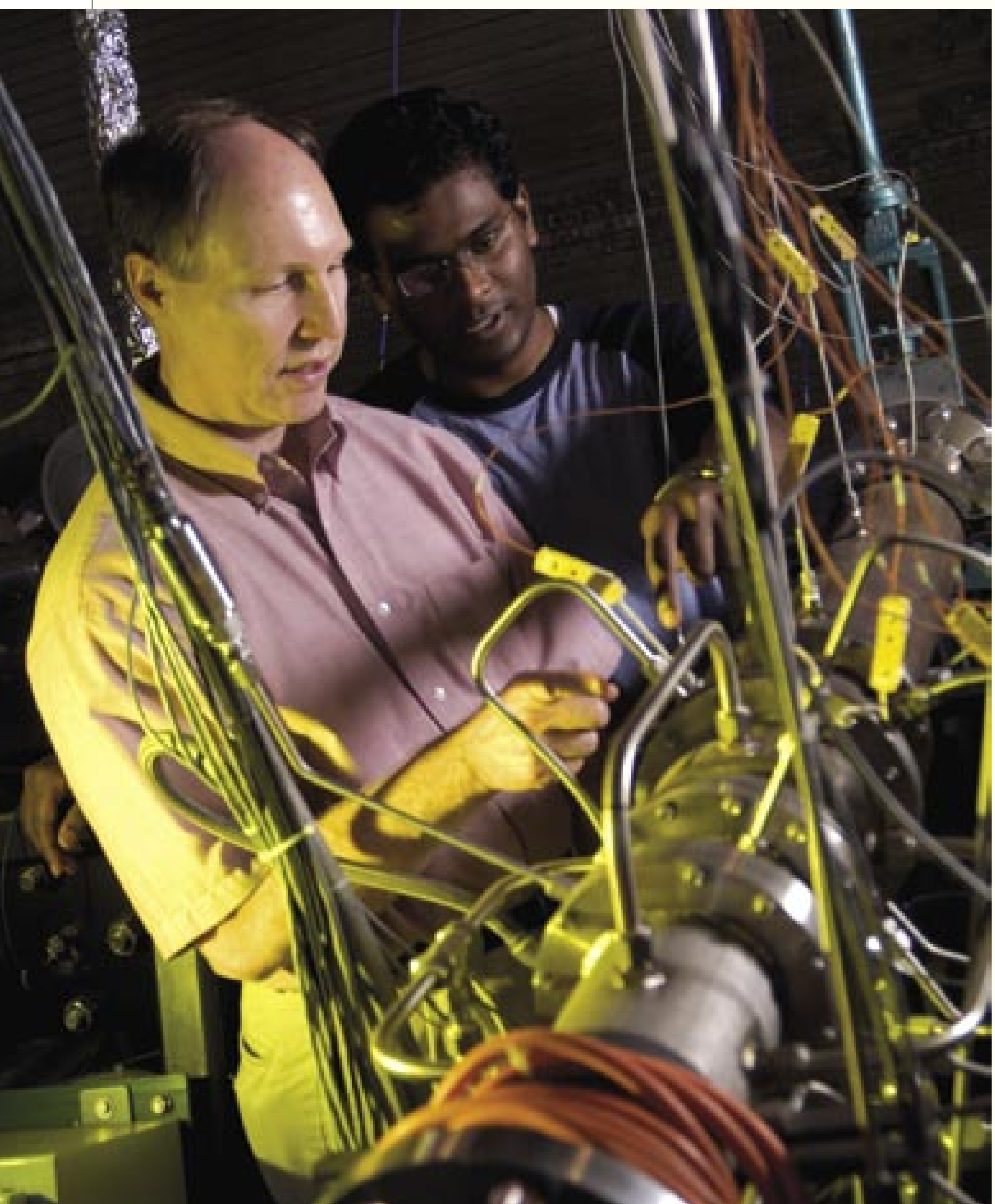
Chemical Colleagues: Arvind Varma (seated), the R. Games Slayter Distinguished Professor of Chemical Engineering and Head, School of Chemical Engineering, is leading a team of chemical engineers who are developing ways to use hydrogen to charge items as small as cell phones. Among his group (left to right) are Victor Diakov, a postdoctoral research scientist; Evgeny Shafirovich, a research scientist; and Moiz Diwan, a graduate student.



Rocket Scientists: A collaborative effort from both mechanical engineers and aeronautical and astronautical engineers is taking place in Purdue's Zucrow Laboratories. The team is developing test facilities in which highly pressurized hydrogen will be used to conduct research on rockets that will travel to the moon at speeds greater than 20,000 miles per hour and on cars traveling up to 300 miles on a single tank of fuel. Among the mix (left to right) are these seven: Issam Mudwar, a professor of mechanical engineering, Yuan Zheng, Scott Flueckiger, Avanthi Boopalan, Varsha Velagapudi, Timothy Fisher, an associate professor of mechanical engineering, and Timothee Pourpoint. Inset photo: a rocket test.

Coal Fever

A Purdue center hopes to develop clean coal technologies that could also help boost the Indiana economy.



Coal Collaborators: Robert Lucht, a professor of mechanical engineering, and Mathew Thariyan, a graduate student, discuss the operation of a gas turbine combustion test facility that will be used for testing the performance of liquid fuels produced from coal.

A vast supply of untapped coal lies beneath Indiana, a rich and relatively inexpensive energy source that with the recent escalation in oil prices is drawing an increasing amount of attention from researchers, industry, and the federal government. With coal in 17 of its counties, Indiana could be a major player in responding to national energy needs. That, in turn, could boost the state's economy.

Indiana's Center for Coal Technology Research (CCTR), located in Purdue's Energy Center at Discovery Park, is sponsoring scientists and engineers who are working to develop technologies to use Indiana coal in an environmentally and economically sound manner. The center, which was established by the Indiana General Assembly in 2002, is funded by the Indiana Office of Energy and Defense Development (OED) and is an integral part of the State Strategic Energy Plan.

Additional support could come from the Federal Energy Policy Act of 2005, which authorized $85 million for research on the transformation of Illinois Basin coal into transportation fuels, an effort to provide cleaner fuels and greater national independence in energy supplies.

The Illinois Coal Basin represents 25 percent of the national total coal reserves. Its eastern portion includes coal-mining counties in the southwest corner of Indiana and in sections in Kentucky and Illinois. Indiana currently mines about 3.5 percent of total U.S. coal production, a primary source for electricity plants.

"The Midwest in general, and Indiana in particular, has an enormous relatively untapped energy source that can increasingly be turned to as the source of future gas and liquid fuels," states the CCTR's 2006 Coal Report.

Foremost among researchers' concerns is the development of the reserves by creating ways to use coal for power generation with nearly zero emissions and limited environmental impact. Among CCTR's responsibilities are the development of technologies to use Indiana coal "in an environmentally and economically sound manner" and an investigation of the reuse of clean-coal technology by-products. Current research supported by the CCTR includes clean coal technologies, coal transportation, Indiana coking coals, and the use of Indiana coal as a transportation fuel.

Researchers with Purdue's Coal Transformation Laboratory (an interdisciplinary team with members from engineering, chemistry, economics, and agronomy) are collaborating with the CCTR to develop technologies to convert coal into combustible gases and liquids that can be burned cleanly while meeting the demand for electric power, heating, and transportation, according to CCTR founder Tom Sparrow, professor emeritus of industrial engineering and former director of the State Utility Forecasting Group. Sparrow is a member of the CCTR's advisory board. The CCTR director, since November 2005, is Marty Irwin, who has an office at Purdue and at the OED in Indianapolis.

Industry has a rapidly growing interest in clean-coal technology, says CCTR's Brian Bowen, who reports that Duke Energy (formerly Cinergy) is considering the clean-coal technology, known as integrated gasification combined cycle technology (IGCC), for its new plant in Edwardsport, Indiana. This technology converts coal into gas that is then burned to generate electricity.

"These are major developments in clean-coal research, and all of industry is watching very carefully because implementation will involve large capital investment," Bowen says.

The world beyond industry also seems to be waking up to the potential of coal. In a spring 2006 Sunday issue, the *New York Times* featured a front-page story that billed coal as "the fuel of the future."

"Coal, the nation's favorite fuel in the 19th century and early 20th century, could become so again in the 21st," the article stated, noting that U.S. coal reserves are far greater than either oil or natural gas. And with help from Purdue researchers, that could translate into an economic gain for the state of Indiana. ●●● —L.T.T.

Midwest Mountains: According to a report published by Indiana's Center for Coal Technology Research, located in Purdue's Energy Center at Discovery Park, "The Midwest in general, and Indiana in particular, has an enormous relatively untapped energy source [in coal] that can increasingly be turned to as the source of future gas and liquids."

Avoiding an Oil Crisis

The Energy Summit brings national leaders to Purdue.

Last summer, Indiana's governor and Ford Motor Co.'s vice president of environment and safety engineering joined other national leaders as part of an energy summit convened by U.S. Sen. Richard G. Lugar and Purdue University to discuss national energy issues.

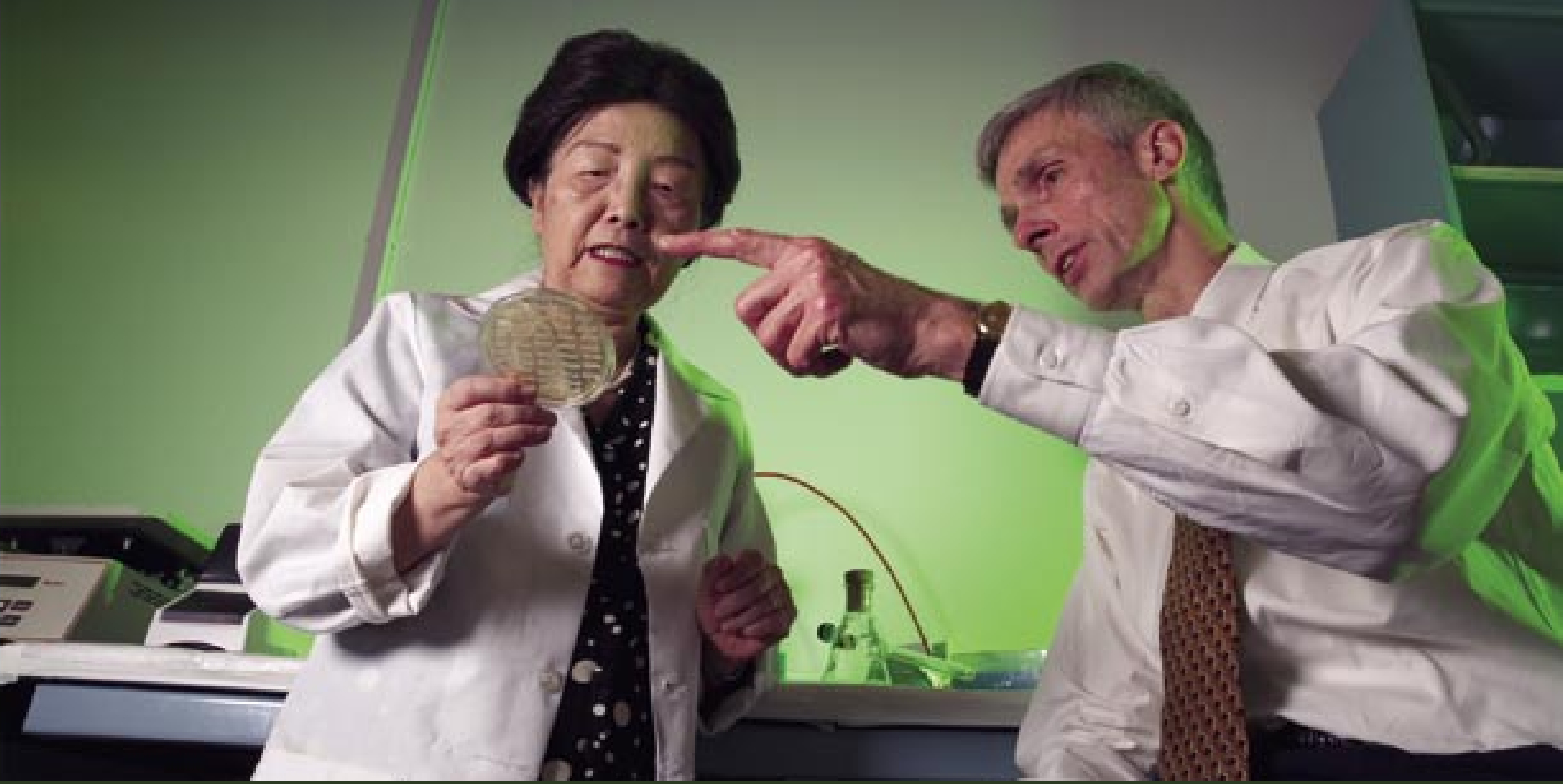
Governor Mitch Daniels opened the Richard G. Lugar-Purdue Summit on Energy Security on August 29. Ford Vice President Sue Cischke spoke as part of a panel discussion on "Implementing Strategies to Reduce Foreign Oil Dependence."

Other panelists were Carol Battershell, vice president for alternative energy for BP Inc., and Amy Myers Jaffe, Wallace S. Wilson Fellow in Energy Studies at the James A. Baker III Institute for Public Policy of Rice University. Brian Lamb, president and CEO of C-SPAN, served as the panel moderator.

In his keynote address, Lugar, who served as chaiman of the U. S. Senate Foreign Relations Committee, called for dramatic and immediate action to address U.S. energy vulnerability. "Neither American oil com-

Photo courtesy of the Purdue University News Service

Energy Strategy: Senator Richard Lugar called for dramatic and immediate action to address U.S. energy vulnerability at the Lugar-Purdue University Summit on Energy Security last August.



Biofuel Specialists: Michael Ladisch, a distinguished professor of both biomedical engineering and agricultural and biological engineering, and Nancy Ho, a research scientist, have both worked for years in Purdue's Laboratory of Renewable Resources Engineering, where researchers have developed genetically modified yeast—known in some circles as the "Purdue Yeast"—thats plays a pivotal role in the development of ethanol.

panies, nor American car companies have shown an inclination to dramatically transform their businesses in ways that will achieve the degree of change we need to address a national security emergency," he said. "Most importantly, the federal government is not treating energy vulnerability as a crisis, despite an increase in energy-related proposals.

"To this end, the United States should adopt a national program that would make virtually every new car sold in America a flexible-fuel vehicle. We should ensure that at least one-quarter of filling stations in America have E85 pumps. We should expand ethanol production to 100 billion gallons a year by 2025, a figure that could be achieved by doubling output every five years.

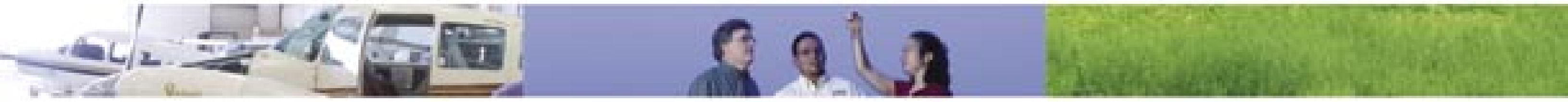
"We should also create an approximate $45 per barrel price floor on oil," Lugar continued, "through a variable ethanol tax credit to ensure that investments keep flowing to alternatives. And we should enact stricter vehicle mileage standards to point automobile innovation toward conservation. The plan I am proposing today would achieve the replacement of 6.5 million barrels of oil per day by volume—the rough equivalent of one-third of the oil used in America and one-half of our current oil imports."

"Our failure to act will be all the more unconscionable given that success would bring not only relief from the geopolitical threats of energy-rich regimes, but also restorative economic benefits to our farmers, rural areas, automobile manufacturers, high-technology industries, and many others," concluded Lugar.

"We must be very clear that this is a political problem. We now have the financial resources, the industrial might, and the technological prowess to shift our economy away from oil dependence. What we are lacking is coordination and political will. We have made choices, as a society, which have given oil a near monopoly on American transportation. Now we must make a different choice in the interest of American national security and our economic future."

For Purdue's part, President Martin Jischke hopes the university will provide a cutting-edge home for researchers looking to develop those alternatives. "Purdue has worked to create an environment in which energy researchers from all disciplines are collaborating to find and develop alternative energy sources and policies to make current energy sources cleaner and more efficient," Jischke told the audience. "The research at Purdue is exploring a number of energy alternatives, including biofuels, liquid fuels, clean-coal technologies, and others." ●●● —**Cynthia Sequin**

Environmental Evaluations



Cleaning up the Barnyard

— SALLY BOND

Through high-tech science, researchers at Purdue's Center for the Environment are helping to set standards on acceptable farm odors.

Farm Fan: Al Heber, a professor of agricultural and biological engineering, has "always been involved in the largest and most comprehensive studies ever done while serving on both sides of the issue," he says. The issue at hand: How much is too much when it comes to foul farm odors? Shown here on a dairy farm in northern Indiana, Heber is directing the National Air Emissions Monitoring Study through Purdue's Center for the Environment. The results of the study will help determine standards for what stinks.

Litigation is giving way to the laboratory. For the next 32 months, livestock farmers across the nation will await the results of a $14 million National Air Emissions Monitoring Study (NAEMS) run by Purdue's Al Heber through the Center for the Environment.

Pigs, chickens, and cows, with their accompanying manure pits, lagoons, and barns, have been the chief culprits in a growing farm odor and air quality dilemma. This national dilemma has been exacerbated by concurrent trends of people moving into the country and by the increasing size of farms. Complaints from neighbors have generated newspaper stories, lawsuits, bands of homeowners working together to prevent new facilities from locating nearby, and even state regulations on odor levels at the surrounding property lines.

Interventions and regulations, however, have been notoriously arbitrary, arguably unfair, and often based on what Heber, a professor of agricultural and biological engineering, refers to as the "bad science" of faulty information and emission data. This year, however, marks the convergence of new technological capabilities, a unique amnesty-esque partnership between the EPA and the livestock industry, and a Heber track record of expertise and collaboration with industry and environmental groups. "I've always been involved in the largest and most comprehensive studies ever done and have served on both sides of the issue," says Heber, the enthusiastically received science adviser for the NAEMS. With ultimate oversight for the entire nationwide study, Heber will lead the effort that has been referred to by livestock producers in terms as dramatic as "the dawn of a new age" and "a new chapter in the regulation of the livestock and poultry industry."

Not-So-Weird Science

"The public and industry alike have a desperate need for science in the area of emission data for commercial farms," explains Heber, "and never before has such an expansive study been proposed that involves close EPA scrutiny and that ensures valid, high-quality data." Over a two-year period, NAEMS will measure air emissions continuously from two to four barns per site with 14 sites spread across the nation. Measurements will build an accurate database of emission information that is finally appropriate for modern animal agriculture and that can be interpreted and drawn on for additional research on air emission control technologies.

After the summer of 2006 and the finalization of more than 1,000 pages of painstakingly precise and reproducible measurement protocols, NAEMS began the two-year data collection process that Richard Grant, a professor of agronomy and the NAEMS project manager, says will stretch standard operating procedures in all levels of measurement activities. NAEMS protocols will dictate precisely where equipment will be placed on a site, the frequency of measurements, and cross-validation and data management procedures. And they will incorporate state-of-the-art technology. The acquired analytical and meteorological data will include, for example, meteorological measurements (wind speed and direction, temperature, humidity, pressure, surface wetness, and solar radiation); lagoon measurements (solids depth, pH, redox potential, temperature, and a map of the topography using length, volume, longitude and latitude through GPS); ammonia and hydrogen sulfide concentrations and emissions measurements; turbulence (3-D turbulence wind components and temperature variability); and carbon dioxide concentration in the air.

NAEMS researchers at Purdue's Air Quality Laboratory will use advanced technology in novel ways to achieve new gains in measurement sensitivity. Heber will apply photoacoustic infrared detection, for example, to measure ammonia concentrations on each farm. The gas samples from barn emissions will be exposed to a pulsing infrared light of a specific wavelength. If ammonia is present, the gas will absorb a proportional amount of the light, which in turn increases the gas temperature and kinetic energy and results in audible pressure pulses that researchers can detect with a very sensitive microphone. The greater the ammonia concentration, the louder the pressure pulse will be.

A Farm by Any Other Name

For farms such as Rose Acre Farms, "a large benefit will simply be the good of science," states Chips Everhart, the director of environmental affairs for the egg farm based in Seymour, Indiana. "This information needs to be done nationwide, and we want to do all we can to move the effort along. A side benefit for each farm is that we'll learn new things about our own operations."

Mike McCloskey, Fair Oaks Dairy owner and manager, sees the NAEMS study as "the first step in showing us what we need to measure and how we need to measure it. But it will also lead to best-practice technology that we can implement in our dairy operations." The baseline data on farm air-emission rates will allow Heber and his Air Quality team to move into developing process-based predictive models. These models will allow research into mitigation strategies that can take into account technical and economic feasibility and also address important community needs. The NAEMS measurement infrastructure will remain for follow-up testing of specific abatement methods and further validation of the models. The improved measurement protocols will produce emission characteristics that will lead to emission and dispersion models. The ultimate goal is improved air quality and the assurance of community acceptability.

The Center for the Environment's three focal areas, monitoring environmental phenomena, modeling, and management, dovetail seamlessly with NAEMS objectives for environmental monitoring and offer a rapid path of research progression. As headquarters for the NAEMS, the center also facilitates vital cross-disciplinary collaborations. Veterinary medicine researchers provide expertise in the consequences of animal care. Health science researchers bring insights on human exposure to environmental phenomena. Agronomists provide meteorological capabilities. And agricultural and biological engineers in the Agricultural Air Quality Laboratory have expertise in collecting experimental data.

"The NAEMS project allows the center to make a difference on a national scale," says Heber. "People nationwide are looking to the Purdue protocol as the standard to use in measurement studies. States are waiting to see study results before proposing important regulations. We were chosen based on our excellent track record, and now, through NAEMS, Purdue has been given the opportunity to take a commanding leadership role in air-quality issues."

Change Gonna Come?

A Purdue collaboration is helping separate facts from fiction on the subject of global climate change.

The two-year-old Purdue Climate Change Research Center (PCCRC) brings climate change issues home—to the Midwest and the Purdue campus. With cutting-edge multidisciplinary research, such as sophisticated com-

Airborne Scholar: Paul Shepson, the director of the Purdue Climate Change Research Center (PCCRC) and a professor of chemistry and earth and atmospheric sciences, often takes to the friendly skies to investigate the effects of global climate change. Research in the PCCRC and other national laboratories builds knowledge on how climate change from increased concentrations of greenhouse gases will have important regional effects.

puter codes for climate modeling that better incorporate environmental complexities, the new PCCRC is playing an integral international role in understanding the global climate challenge.

Research in the PCCRC and other national laboratories builds knowledge on how climate change from increased concentrations of atmospheric greenhouse gases will have important regional effects. Coastal areas around the world may deal with severe storms and sea-level rises that can cause coastal erosion, and regions such as the Alps and the Rocky Mountains may contend with diminished snowmelt that changes the water resource supply. Effects in the U.S. Midwest will focus more on agricultural issues and crop productivity as changes occur in precipitation, extreme weather events, pest populations and disease transmission, erosion, and water quality.

"However, our mission is not limited to studying a complex global phenomenon," says Paul Shepson, director of the PCCRC and a professor of chemistry and earth and atmospheric sciences. "We want to educate the community on how climate change affects us on a regional scale and how we can mitigate and adapt in a local capacity. All that knowledge is useless unless we do something about it."

PCCRC's outreach mission at Purdue has begun with an inaugural campus-wide carbon management class (spring 2007) that focuses on creating a "carbon neutral" West Lafayette campus for no net contributions to atmospheric carbon dioxide. "Our goal is to minimize Purdue's carbon footprint," says Shepson, "and this means educating our community about buildings being managed by burning huge amounts of coal. We can do the right thing for our planet while saving Purdue money."

PCCRC's carbon management ideas include using motion sensors in hall lights, building a better infrastructure for campus bicycling, and challenging wasteful energy consumption habits, such as healthy people calling elevators to ride only a few floors or pushing handicap buttons to open doors.

The roster of PCCRC researchers reflects the complexity of science and public policy in climate change and also the broad scope of the center's mission. PCCRC educators and researchers represent earth and atmospheric science, civil engineering, agronomy, biology, chemistry, forestry, agricultural economics, agricultural and biological engineering, political science, management, and education...and they may be coming soon to a community near you. Outreach efforts include working with local officials on community carbon management plans, developing educational materials, and conducting "road shows" to educate people about climate change research and mitigations. Make room, too, on your family bookshelves for Shepson's soon-to-be-released children's book on climate change in the Arctic.

●●● —**S.B.**

Purdue Engineering Creates Environment, Ecology Division

Purdue's College of Engineering has created a new academic division in the environmental and ecological field that will help foster research, offer seminars, and give students a greater overall understanding of how engineering affects the environment.

"Engineers have vast opportunities to promote positive effects on our environment through the work they do," says Leah Jamieson, the John A. Edwardson Dean of Engineering. "Not only have Purdue students expressed a strong interest in pursuing courses in environmental engineering, but also we have felt it was important to Purdue to incorporate environmental studies across the engineering curriculum."

Nationally, interest in the environmental and ecological field is increasing. According to a 2002 study by the National Science Board, it is projected that there will be a 27 percent increase in the number of environmental engineering positions in the current decade. Inez Hua, an associate professor of civil engineering, will serve as founding interim head of Purdue engineering's new Division of Environmental and Ecological Engineering. "Inez Hua is internationally respected for her research,

Green Research: Loring Nies, an associate professor of civil engineering, and Mi-Youn Ahn, a postdoctoral researcher, are looking into the harmful effects of flame retardants on the environment. In fall, they pull mud from this celery bog near the Birck Boilermaker Golf Course and examine the microorganisms within it.

Chemical Reactions: Inez Hua, an associate professor of civil engineering who will serve as the founding interim head of Purdue engineering's new Division of Environmental and Ecological Engineering, is shown here with colleague Chad Jafvert (left), a professor of civil engineering, and Juan Bezares, a PhD student. The trio is studying how certain chemicals will react when exposed to sunlight.

especially in the areas of water pollution control and environmental chemistry," Jamieson says. "She has begun work in the area of industrial ecology and sustainability engineering, which are key areas for engineering, industry, and the environment. She also has worked with the U.S. Environmental Protection Agency."

Within the Purdue College of Engineering, many of the schools offer courses related to the environment. For example, the School of Mechanical Engineering offers courses about noise control and combustion; the School of Nuclear Engineering offers courses on radioactive waste treatment, and the School of Industrial Engineering offers a course about integrating environmental considerations into facilities planning.

Moreover, the School of Civil Engineering and the School of Agricultural and Biological Engineering offer a substantial number of environmental engineering courses. These courses include remediation of contaminated soils and sediments, industrial and solid waste treatment, water and wastewater treatment, air pollution measurement and control, urban and agricultural air and water quality management, understanding the environmental fate of pollutants, and sustainable engineering.

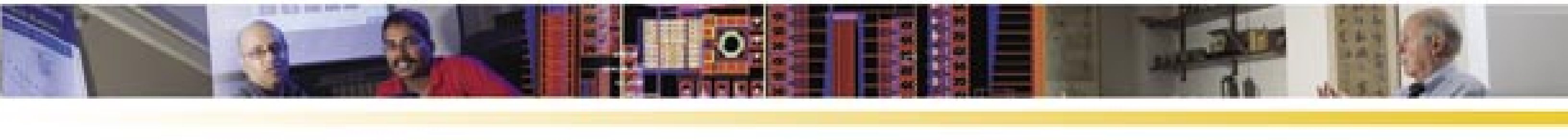
"In fact, more than 50 graduate and undergraduate courses that incorporate environmental considerations in the topics are currently listed with the College of Engineering," Hua says. "One objective of the new division is to coordinate those many course offerings into a coherent program that will highlight the existing strengths of our faculty."

Goals of the new environmental and ecological division include developing an environmental engineering community within the Purdue faculty and promoting student recruitment to the field.

The new division also will

- Develop an environmental and ecological seminar series that complements existing series offered through Purdue's other colleges and schools, as well as Discovery Park's Center for the Environment.
- Develop an environmental and ecological minor for all engineering majors.
- Investigate certificate and graduate degree programs in environmental and ecological engineering. ●●● —C.S.

Global
Happenings



Extending Engineering

—KATHY MAYER

By partnering with international universities and taking technical experts overseas, the Purdue College of Engineering is achieving a global reach.

Long a hotbed for international students seeking a top engineering education and professors traveling worldwide to share their knowledge, the College of Engineering is now sailing into expanded international waters.

Leading the fleet: the just-launched Global Engineering Programs, with the goals of greater internationalization experiences on campus, increased study and work abroad, and the development of new programs. The plan is to enhance and unify current international efforts and expand opportunities for students and professors, says Daniel Hirleman, the William E. and Florence E. Perry Head of the School of Mechanical Engineering, who is also serving as interim director of Global Engineering Programs.

Global Necessity

"The imperative for global engineering has become widely recognized in the last handful of years," Hirleman says. "Studying abroad used to be kind of a luxury, especially in engineering, where accredited curricula don't have much flexibility. In the 1970s it was a nice thing to do. But now, being prepared to immediately function in the global workplace is a necessity."

Beyond traveling, studying, and working in other countries, Hirleman also envisions changes in campus course work at home. "We need multiple pathways for students to raise their global competence. We envision globally inspired homework problems and projects in our courses, where you must comprehend that different cultures define and solve problems differently," he says.

Another approach is offering distance team projects, as he did last year for mechanical engineering seniors at Purdue and at Mexico's Instituto Tecnologico y de Esudios Superiores de Monterrey.

Now, after a year of study and planning, the 17-member Global Engineering Programs team has embraced a vision of preeminence in educating engineers for global professional competition and

Going Global: Daniel Hirleman, the William E. and Florence E. Perry Head of the School of Mechanical Engineering, shown here with Yating Chang in the Burton D. Morgan Center for Entrepreneurship, is hoping an entrepreneurial approach of the newly launched Global Engineering Programs will lead to greater internationalization experiences for students and professors. Hirleman is the interim director of the program, and Chang came on board last July as the assistant director.

International Backer: Riall Nolan's office is filled with trinkets and items brought back from various places overseas. The Purdue associate provost, who is also dean of International Programs and a professor of agricultural economics, is adamant about students pursuing well-rounded, worldwide education. He says, "Tomorrow's engineers must be able to deal globally."

research and education collaborations. An assistant director, Yating Chang, came on board in July.

Its vision is an idea whose time has come, especially for knowledge-based activities, according to a former U.S. secretary of state, Madeleine Albright. That's what students heard early in 2006 when she spoke during National Engineers Week at Purdue on "Globalizing the World's Technology Supply."

"It's a stereotype that globalization affects only factories and low-tech jobs," Albright told the audience. "The skills and knowledge gap is narrowing. Purdue alumni will be judged against Shanghai, Singapore, Malaysia, and Dubai."

Purdue associate provost Riall Nolan absolutely agrees. "Tomorrow's engineers must be able to deal globally," says Nolan, also dean of International Programs and a professor of agricultural economics. Like the 4,831 international students enrolled at Purdue for the 2005/2006 academic year, Purdue's U.S. students also need to experience study in another country, he believes.

Real-World Realities

"You can be a heck of a Purdue engineer—we're one of the best engineering schools—but do you know how to work with Germans, Japanese, Chinese, to develop fuel-efficient vehicles? Can you work on a cross-national team to put the next man or woman on the moon? That's the challenge," Nolan says. "We need to work with others in the world. We need to make sure our engineers get real-world experience."

One place where that's already happening is in the Global Engineering Alliance for Research and Education

Home, Again: Shown here in front of the new Biomedical Engineering Building, Jenna Miller, a biomedical engineering senior, spent part of her summer in Spain participating in the Summer Undergraduate Research Fellowships program. The European experience not only provided her with some early research experience, but also allowed her to experience other cultures.

(GEARE), this fall beginning its fourth year and expanding to include students from five universities—Purdue; Universitat Karlsruhe, in Germany; Shanghai Jiao Tong University, in China; Indian Institute of Technology Bombay, in India; and Monterrey Tech, in Mexico. Originating in mechanical engineering, GEARE now also includes students in aeronautics and astronautics, as well as chemical, civil, and electrical and computer engineering. In the 24-month program, undergraduates learn language and culture, spend a semester studying outside their home country, complete an international internship, and participate on a design team with students from partner universities. Design projects have included a four-person carousel, an off-road autonomous vehicle, a robot that climbs and cleans high-rise windows, and attachments for a single-axle tractor for work on small farms and yard maintenance. In GEARE's first three years, 37 Purdue students participated.

Another area with an international component is the Summer Undergraduate Research Fellowships (SURF), which took biomedical engineering senior Jenna Miller to Spain this summer. "From a scientific perspective, I believe there is some global unity," she says. "Outside of the scientific world, many disparities must be overcome before common ground is achieved on a global scale." She's seen that stereotypes often prevail. "No matter the country, we are all guilty," she says. "It's often easy to perceive individuals as representatives of an entire nation. At times I have felt like an American ambassador on topics ranging from music to international relations." Much of the work ahead will be in global understanding, not just the lab, Miller adds.

Global Engineering Programs will be focusing on that, Hirleman points out. During Global Engineering Week, October 23 to 27, 2006, Purdue hosted its first global opportunities fair, organized by the universities participating in GEARE. In November 2007, Purdue will host the 10th Colloquium on International Engineering Education. And the School of Mechanical Engineering is taking steps to implement a global engineering certificate. "The global workplace is changing rapidly," Hirleman says. "We must change our education system and experiences to prepare our students for this environment."

Teaching Overseas

Although the push for engineering students to study outside the United States is a recent focus, Purdue professors have long been teaching around the globe. Two with global experience are Rudolf Eigenmann, a professor of electrical and computer engineering, and Kaushik Roy, the Roscoe H. George Professor of Electrical and Computer Engineering.

After spending a sabbatical semester in 2005 at the Universitat Politecnica de Catalunya (UPC) in Barcelona, Spain, and teaching a 10-week course on automatic parallelization, Eigenmann returned in 2006 to teach this course as a 10-day intensive graduate class.

"Their research program is one of the best in Europe in this area," he says of the Spanish university, which gave him the opportunity to meet leading researchers posted there and those who

Nanotechnology Overseas: Kaushik Roy, the Roscoe H. George Professor of Electrical and Computer Engineering, has taught low-energy computing and communications/VLSI nanoscale design in Brazil, Mexico, Japan, Korea, Thailand, China, India, Taiwan, Ukraine, and several European countries. His travels have also helped him to recruit students to Purdue. Inset: Among his current graduate students are (clockwise from first seat left): Patrick Ndai from Kenya; Karakonstantis Georgios, from Greece; Myeong-Eun Hwang, from Korea; Mesijit Meterelliyoz, from Turkey; Adam Fruehling, from the U.S.; Dheepa Lekshmanan, from India; and Jing Li (seated), from China.

were visiting. The contacts he made will help initiate international research efforts, he believes, and "I have started a discussion with UPC faculty to possibly initiate a student exchange program."

Roy has taught low-energy computing and communications/VLSI nanoscale design in Brazil, Mexico, Japan, Korea, Thailand, China, India, Taiwan, Ukraine, and several European countries. He's also been a visiting scientist at Nan Yang Institute of Technology, in Singapore, where he regularly visits to evaluate its graduate program and to serve on student thesis committees.

His travels help him recruit students to Purdue, and that diversity on campus is important, he believes. "It brings in different points of view, different thinking, not only in research, but in the learning of different cultures. That's of tremendous benefit and help to Purdue students. And it helps us in having more tolerance."

As for a globalized future, that's a given for today's students, Roy says. "To be a successful student and to be a success after graduation, it's quite important to work not just with people in Indiana, not just in California, but with people from around the world."

Research, Too, Takes a Global View

Imagine an industry—any industry anywhere in the world—looking for or selling some part. What transcends language when buyers and sellers of different cultures and different languages try to get together? A visual.

If only there were a Google for images. Now there is, thanks to the research of Karthik Ramani, a professor of mechanical engineering and director of the Purdue Research and Education Center for Information Systems in Engineering. Best of all, the image need not be a photograph or a professionally created design. It can be a freehand sketch—a doodle even.

Ramani's patented research findings have been licensed by Imaginestics, a software and services company he cofounded in December 2002, that today is headquartered in the Purdue Research Park. The company has since created the world's first search engine for design and manufacturing. "We've launched a 'Yellow Pages' for designers and manufacturers," he explains.

Known as 3Dseek, the software debuted in fall 2005. By early 2006, it already contained an index of more than 40,000 parts, and it continues to grow as suppliers upload their files or the system itself discovers new parts online. Public access is available at www.3d-seek.com.

In its short history, the company has landed funding and awards from key sources for its universal-language product. These have included funding from the National Science Foundation Small Business Innovation Research Program and Indiana's 21st Century Research and Technology Fund. Imaginestics also was a finalist for the 2006 Innovation of the Year Award from Techpoint, an Indiana technology trade group.

"I saw globalization coming about seven or eight years ago," Ramani says. "More than reading Thomas Friedman's book *It's a Flat World*, I'm part of that whole thing," he says, referring to Friedman's contention that technology has made the world a level—or flat—playing field for companies anywhere.

"I saw Google doing text-based searches," Ramani says. "And I saw the need for people to search for things without having to know part names or different languages. If we could come up with something that could find objects without having to know words to describe them, it could be useful."

He did. And today Imaginestics' products include the search-shape search engine; an engineering advisory

Image Makers: Karthik Ramani (center), a professor of mechanical engineering and director of the Purdue Research and Education Center for Information Systems in Engineering, has created a virtual Google for images for designers and manufacturers. Shown here with PhD students Min Liu (left) and Yagna Kalyanaraman, Ramani cofounded a company called Imaginestics and later released the software known as 3Dseek, which continues to grow with an index of more than 40,000 parts.

system; an enterprise-wide product configurator; an interactive, configurable online parts catalog; and a tool for intelligent design content extraction, matching, and locating. They're used primarily in the manufacturing world, but future software could be created for everyday shoppers looking for home repair items or other products.

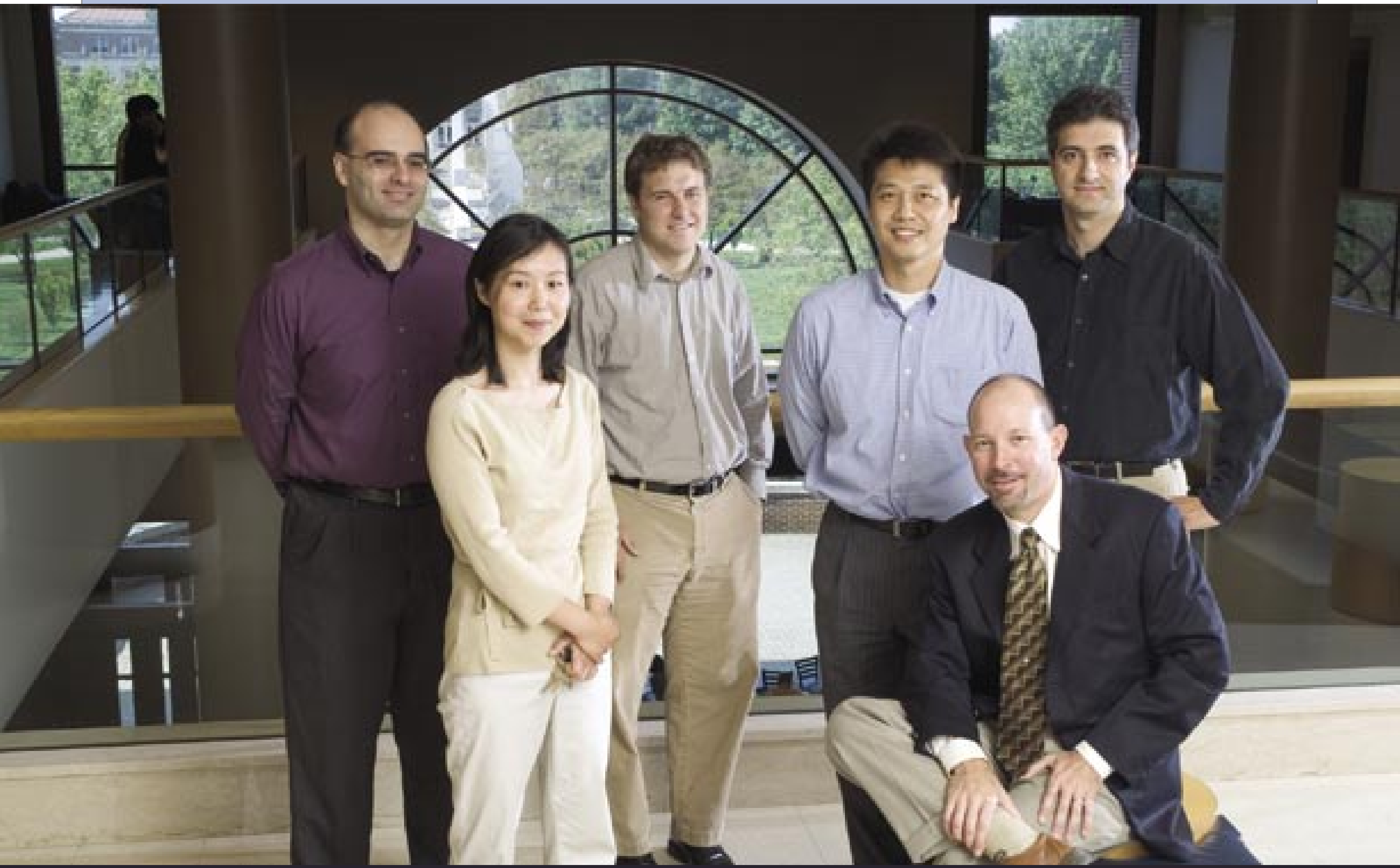
"This is a new area we created, a new area of research," Ramani says. "Shape similarity is a very hot idea now. We set the tone. No one else has an online search engine like this.

"Our research becomes real very quickly; it's a very interesting dynamic. In the past, we'd have white papers, research that would go nowhere. Now I'm trying to make it real. I'm learning what the real problems are, what people need before anybody even knows it."

For more about Imaginestics, visit the company's Web site at www.imaginestics.com. ●●● **—K.M.**

No Borders

The Center for Wireless Systems and Applications designs innovative solutions that break the shackles of geography.



Worldwide Wireless: A diverse team, with researchers from various parts of the world, is collaborating in the area of Microwave and Applied Electro-Magnetics, otherwise known as MEMS. Among the group (left to right) are five assistant professors of electrical and computer engineering, including Dimitrios Peroulis, Dan Jiao, William Chappell, Byunghoo Jung, and Saeed Mohammadi, along with Edgar Martinez (seated), an assistant dean of engineering for research and entrepreneurship.

Schools and departments across campus are combining their individual strengths through the Center for Wireless Systems and Applications (CWSA). This university-wide initiative promotes the evolving, multi-disciplinary world of wireless systems and applications through projects that have a societal impact—and through solutions not confined by geography.

"It's a broad-based center," says Ness Shroff, CWSA director and a professor of electrical and computer engineering. "We want to create some synergy between all of the individual activities taking place in various research organizations within Purdue." The center also relies on industrial partners to help define CWSA activities.

The center's major thrust areas include devices and materials, low-power electronics, wave-based systems (radio and nonradio), communications, networks, and multimedia. The following represent just a few projects currently under way.

Monitoring Internal Environments

CWSA members are designing ways for the Chao Center, a stand-alone pharmaceutical unit, to monitor its internal environment. Instead of visiting the center every few days to take measurements and collect data, researchers will use sensors to monitor conditions like temperature and humidity—factors essential to ensuring product quality. If humidity falls below a prescribed threshold, for example, control systems would be enabled to automatically adjust the humidity level.

This will allow the Chao Center to remedy environmental problems, helping it to meet FDA requirements through a greater degree of quality control. "We hope that if this takes off it will have a huge impact on how the pharmaceutical industry does future monitoring," Shroff says.

Promoting Battleship Efficiency

Through a partnership with Crane Naval Research—and several faculty members from mechanical engineering, electrical and computer engineering, computer science, and a startup company called Simulex—researchers are creating high-fidelity, sophisticated simulations of battleship environments, determining what might happen in certain situations. This entails studying how a ship's crew would respond, how wireless systems would work, and what could be done to upgrade those systems.

An important objective of the project is to make a crew's job paperless, designing communication in such a way that sailors won't need to run back and forth across the ship. To increase a ship's reliability, the CWSA will study communication systems, power systems, the crew's movements, and information dissemination. Researchers must also consider potentially high-stress conditions like battlefield attacks.

Informing and Entertaining the Masses

Fans at Purdue's Ross-Ade Stadium already enjoy features of the e-Stadium, another CWSA project in collaboration with ITaP (Information Technology at Purdue) and the athletics department. By using handheld personal digital assistants (PDAs), they can access high-tech services via the e-Stadium's Web page.

Should fans want to access a player's bio, they can use their PDA. If they want to see the last exciting play, they can download instant-replay video clips within 30 seconds of the action. "All of that is at your fingertips," Shroff says. Designers also hope to add a "people finder" function with which fans can find out where their friends are seated in the stadium.

The project uses wireless access points located throughout the stadium. This requires a high-quality code and a strong bandwidth—especially as more people access these services. The project's designers will also explore the feasibility of making these features available on display-capable cell phones. ●●● **—Matt Schnepf**

Indiana First: Purdue Dedicates the Biomedical Engineering Building

On Friday of Homecoming weekend in 2006, Purdue dedicated its $25 million biomedical engineering building—an Indiana first.

The building is a joint investment between the state of Indiana and private donors and will be home to the Weldon School of Biomedical Engineering. The four-story building will house highly specialized laboratories for biomedical research and development and integrated educational facilities that will involve students in real-world research activities. Many of the projects involve partnerships with Indiana medical device and biotechnology companies specializing in orthopedic, cardiovascular, and tissue engineering technologies.

"The need for biomedical engineers in industry and healthcare environments, as well as academia, will continue to grow," says George Wodicka, head of biomedical engineering. "This unique building is a flagship for the field. It will allow us to increase the scale and scope of our research to address a broader set of challenges in preventing, diagnosing, and treating disease and will increase our instructional capacity to meet the future demand."

The 91,000-square-foot building has three floors above ground and a basement. The first floor will be primarily used for undergraduate and graduate educational programs and will house hands-on instructional laboratories, advising and counseling offices, classrooms, and meeting space for students. The second and third floors and the basement will be dedicated to interdisciplinary research, housing six core research laboratories concentrating on biomaterials and tissue engineering, biomedical imaging and optics, bionanotechnology and biosensors, neural engineering, orthopedic biomechanics and implants, and computational and systems biology.

Modern communications features in the new structure will enable researchers at Purdue and other institutions around the world to collaborate on research and educational projects remotely.

BSA LifeStructures, an Indianapolis architectural firm, designed the glass, brick, and metal building. Maregatti Interiors in Indianapolis provided interior design services. The facility has halls that connect its wings around a central area—a three-story space that promotes interactions among students, staff, and faculty.

—C.S.

Building Biomed: This past Homecoming weekend, officials assembled a slide rule key to symbolize the official dedication of Purdue's new building that houses the Weldon School of Biomedical Engineering. From left are George Wodicka, head of the School of Biomedical Engineering; Peter Katona, past president and CEO of the Whitaker Foundation; Purdue President Martin Jischke; and biomedical engineering student Lester Smith of New Orleans. Jischke also shares a moment with Leslie Geddes and his wife, LaNelle. Geddes is the Showalter Distinguished Professor Emeritus of Biomedical Engineering.

Neil Armstrong Hall of Engineering (ARMS)

Armstrong Rising: With a few schools and a host of programs set to move into the building in the summer of 2007, the Neil Armstrong Hall of Engineering is rapidly on the rise.

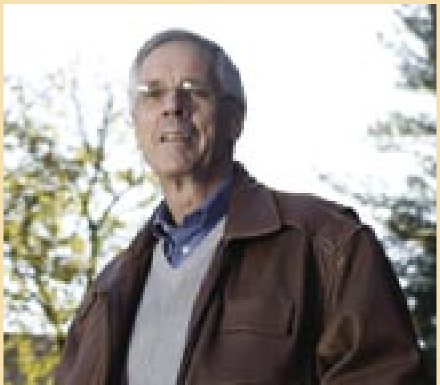
As the academic and physical gateway to Purdue Engineering, Armstrong Hall will be where many take their first steps to become engineers. This facility will house Engineering Administration, Aeronautics and Astronautics, Engineering Projects in Community Service (EPICS), Engineering Education, Materials Engineering, the Minority Engineering Program, and the Women in Engineering Program.

Armstrong Hall is designed to provide the unique educational and research facilities dedicated to teamwork, hands-on learning, building community relationships, and establishing interdisciplinary connections necessary for educating the next generation of engineers. The building will have 109,000 assignable square feet, including more than 20,000 dedicated to research labs and more than 60,000 for undergraduate teaching facilities and discipline-specific design labs. Armstrong Hall will feature learning spaces in eight classrooms that will facilitate student teamwork, especially for design studies, one of the most important facets of engineering education.

A key feature of Armstrong Hall is the concept of Team Learning Modules (TLM), which will alllow students to experience the entire engineering life cycle. This concept addresses a common theme emanating from our alumni and industry advisers. Industry is demanding engineers who have traditional technical expertise along with design-and-build experience, often on industrial scale projects, and who can work on diverse teams.

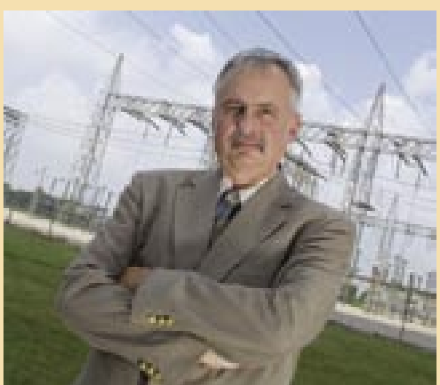
Students, faculty, and staff can expect to occupy the building in the summer of 2007, with classes starting in the fall. ●●● **—Jenna Rump**

Faces Across Campus



John Sullivan

Audeen Fentiman



Oleg Wasynczuk

Many researchers within the College of Engineering have established themselves as world-renowned experts in various fields. And whether they've spent careers at Purdue or have been recruited to further their work here, the promise of research facilities in Discovery Park and elsewhere are helping them reach the pinnacle of success. A few of the faces in that crowd include the following.

John Sullivan, a professor of aeronautics and astronautics, has spent 31 years at Purdue. As director of Purdue's Center for Advanced Manufacturing, Sullivan helps bring research expertise to the industries that will most benefit from it. "Taking the manufacturing summit to regional sites allows busy manufacturers to take a short break and learn about success stories and the resources that are available to them," he says. "In addition to the networking and sharing of ideas, we expose attendees to information and resources they can put to use immediately." Part of Sullivan's own success story includes his recent appointment to the nine-member NASA Advisory Council.

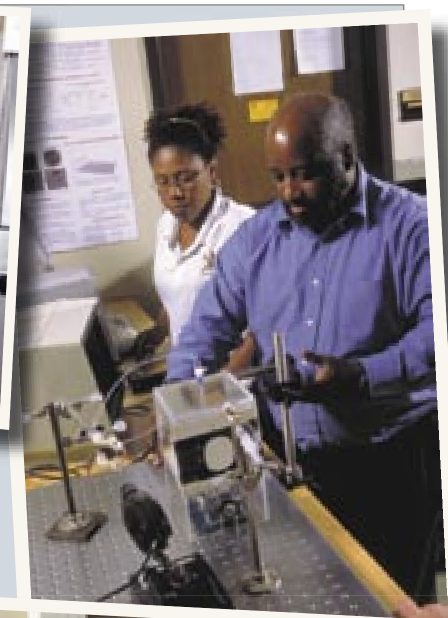
A new arrival in West Lafayette in the spring of 2006 was **Audeen Fentiman**, a professor of nuclear engineering and the associate dean of graduate education for Purdue's College of Engineering. Fentiman brings industry expertise to campus on the nuclear fuel cycle and radioactive waste management. Weighing in on that hot topic, she says, "Recycling is both wise and safe when it comes to nuclear waste. Plutonium is a great fuel for reactors, for example. One of the safest things to do is to blend it back into fuel to be used for energy."

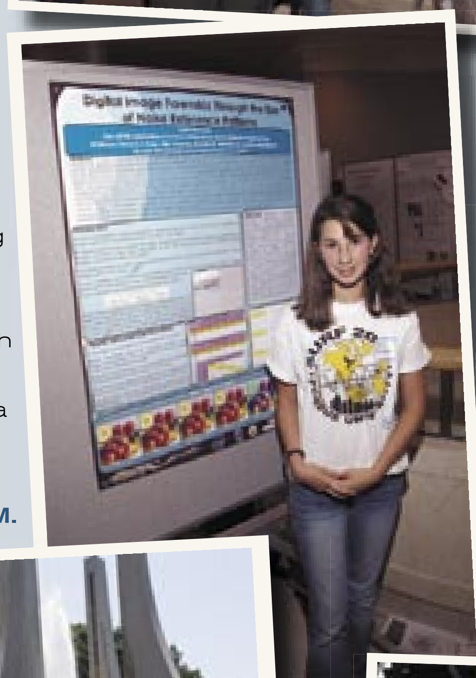
Oleg Wasynczuk, a professor of electrical and computer engineering, is director of Purdue's Center for Security of Large-Scale Systems, part of Purdue's Homeland Security Institute. The center is developing new devices and control/operating methodologies for security enhancement. Its research and development areas include electric power systems for high-altitude airships and the electric power grid, along with other initiatives.

SURF Swells at Purdue

As Purdue's Summer Undergraduate Research Fellowships (SURF) program continues to grow, the surging numbers speak for themselves. Last summer, 176 students with an average grade point average of 3.42 participated in the program. Of those students, 42 came from other schools, and the total numbers have grown to include 30 percent female students and 14 percent minorities.

The students worked in labs, participated in a poster session detailing their research findings, and gained a greater understanding of the research world. On the mentoring side, 115 Purdue faculty members and 159 graduate student mentors helped guide the SURF students. With projects in 21 different schools and departments, students had a plethora of options for digging their hands into the cutting edges of science and engineering. ●●● —W.M.





SURF's Up: This past summer, 176 students participated in Purdue's Summer Undergraduate Research Fellowships (SURF) program, where they presented their findings in a poster session after working with the likes of (second column, top to bottom) Michael Harris, a professor of chemical engineering; Patricia Davies (center), a professor of mechanical engineering; and R. Byron Pipes (right), the John Leighton Bray Distinguished Professor of Engineering.

Featured Engineers

Please contact for more information.

Arden Bement, Nuclear Engineering	**bement@purdue.edu**
Chip Blatchley, Civil Engineering	**blatch@purdue.edu**
Yating Chang, Mechanical Engineering	**yatingchang@purdue.edu**
William Chappell, Electrical and Computer Engineering	**chappell@ecn.purdue.edu**
Patricia Davies, Mechanical Engineering	**daviesp@purdue.edu**
Rudolf Eigenmann, Electrical and Computer Engineering	**eigenman@purdue.edu**
Audeen Fentiman, Nuclear Engineering	**fentiman@purdue.edu**
Tim Fisher, Mechanical Engineering	**tsfisher@purdue.edu**
Leslie Geddes, Biomedical Engineering	**geddes@purdue.edu**
Jay Gore, Mechanical Engineering	**gore@ecn.purdue.edu**
Al Heber, Agricultural and Biological Engineering	**heber@purdue.edu**
Daniel Hirleman, Mechanical Engineering	**hirleman@ecn.purdue.edu**
Nancy Ho, Laboratory of Renewable Resources Engineering	**nwyho@purdue.edu**
Inez Hua, Civil Engineering	**hua@purdue.edu**
Joseph Irudayaraj, Agricultural and Biological Engineering	**josephi@purdue.edu**
Monika Ivantysynova, Agricultural and Biological Engineering and Mechanical Engineering	**mivantys@purdue.edu**
Leah Jamieson, Electrical and Computer Engineering	**lhj@purdue.edu**
Chad Jafvert, Civil Engineering	**jafvert@purdue.edu**
Dan Jiao, Electrical and Computer Engineering	**djiao@purdue.edu**
Martin Jischke, Aeronautics and Astronautics	**mcjischke@purdue.edu**
Byunghoo Jung, Electrical and Computer Engineering	**jungb@purdue.edu**
Michael Harris, Chemical Engineering	**mtharris@ecn.purdue.edu**
Michael Ladisch, Agricultural and Biological Engineering	**landisch@purdue.edu**
Mark Lawley, Industrial Engineering	**malawley@purdue.edu**
Robert Lucht, Mechanical Engineering	**lucht@purdue.edu**
Edgar Martinez, Office of Research and Entrepreneurship	**martinez@purdue.edu**
Saeed Mohammadi, Electrical and Computer Engineering	**saeedm@ecn.purdue.edu**
Issam Mudawar, Mechanical Engineering	**mudawar@purdue.edu**
Loring Nies, Civil Engineering	**nies@purdue.edu**
Joseph Pekny, Chemical Engineering	**pekny@purdue.edu**
Dimitrios Peroulis, Electrical and Computer Engineering	**dperouli@purdue.edu**
R. Byron Pipes, Materials Engineering	**bpipes@purdue.edu**
Tim Pourpoint, Aeronautics and Astronautics	**timothee@purdue.edu**
Karthik Ramani, Mechanical Engineering	**ramani@purdue.edu**
Rex Reklaitis, Chemical Engineering	**greklait@purdue.edu**
J. Paul Robinson, Biomedical Engineering	**joseph.p.robinson.1@purdue.edu**
Kaushik Roy, Electrical and Computer Engineering	**kaushik.roy.1@purdue.edu**
Ness Shroff, Electrical and Computer Engineering	**shroff@ecn.purdue.edu**

Tom Sparrow, Industrial Engineering	**fts@ecn.purdue.edu**
John Sullivan, Aeronautics and Astronautics Engineering	**john.p.sullivan.1@purdue.edu**
Arvind Varma, Chemical Engineering	**avarma@purdue.edu**
Venkat Venkatasubramanian, Chemical Engineering	**venkat@purdue.edu**
Oleg Wasynczuk, Electrical and Computer Engineering	**wasynczu@ecn.purdue.edu**
George Wodicka, Biomedical Engineering	**wodicka@purdue.edu**
Yuehwern Yih, Industrial Engineering	**yih@purdue.edu**

Credits

Editor	**William Meiners**
Designer	**Swapnil Mathkar**
Writers	**Sally Bond** **Kathy Mayer** **Matt Schnepf** **Cynthia Sequin** **Linda Thomas Terhune** **Gina P. Vozenilek**
Copy Editor	**James Keating**
Interns	**Vicky Ortiz** **Billy Peck** **Jenna Rump**
Photographer	**Vincent Walter**
Other Photography Credits	**Yuehwern Yih** **HydroQual** **Purdue News Service**
Stock Photos	**Istockphotos.com**
Produced by the Engineeing Communications Office	**Rwitti Roy, Director**

PURDUE
UNIVERSITY

COLLEGE OF ENGINEERING

Office of Research and Entrepreneurship
Potter Engineering Building, Room 322
500 Central Drive
West Lafayette, IN 47907-2022
765-494-2122
engineering.purdue.edu/research