

PURDUE *weaves* **TAPESTRY** *of*
DISCOVERY *with* **DELIVERY...**



PURDUE
UNIVERSITY



From the
PRESIDENT >>

Meeting global challenges

Purdue University investigators campus-wide are intent on addressing

global challenges by focusing their research efforts on creating new knowledge and applying innovative solutions for the common good. We are increasing our global footprint by building new partnerships with leading institutions in many nations.

On campus, Purdue proudly hosts nearly 5,500 students from 120 countries, the second largest population of international students at a public institution. The contributions made by our diverse population of faculty, students and staff are among our prized values. International investigators and students are essential participants in the discovery process and enrich the social and cultural fabric of our campus.

Collaborative partnerships and Purdue's international and diverse population are both essential ingredients in creating a dynamic environment for learning and discovery. Purdue is uniquely poised to assist in meeting the global challenges facing our society.

—France A. Córdova, *President*

From the **VICE PRESIDENT**
for **RESEARCH** >>

Promoting discovery with delivery

A legacy of research is intrinsic to the success of any research institution and, as you will read in the following pages, investigators at Purdue are building on a foundation of discoveries in an environment where the exchange of ideas between multiple disciplines is encouraged. Purdue researchers are breaking through disciplinary boundaries and advancing research discoveries that have the potential to improve the quality of life for people around the state and nation, and throughout the world. A unique pipeline for innovation has been created through the partnerships throughout the University. Together they are yielding impressive results. Purdue is answering the call for discovery with delivery.

—Richard Buckius, *Vice President for Research*



From the **PROVOST** >>

Launching tomorrow's leaders

Faculty at Purdue are preparing graduate students for the challenges of the 21st century through programs that build on disciplinary goals and encourage the development of leadership skills for a multicultural environment.



In addition, the commitment by Purdue faculty to engage undergraduate students in the discovery process is inspiring a new generation of researchers and scientists. Exceptional undergraduate students, students from abroad and from other U.S. institutions are involved in challenging research opportunities at Purdue. Undergraduate students also are preparing to become the next generation of entrepreneurs by participating in the Certificate of Entrepreneurship and Innovation Program. Purdue offers a rich environment for students seeking new knowledge and hands-on experiences in discovery. The University is dedicated to launching tomorrow's leaders.

—Randy Woodson, *Provost*

Inside »

- « **From Purdue to the world**
Messages from Purdue President France Córdoba,
Provost Randy Woodson and Vice President for
Research Richard Buckius
- 1 Purdue weaves tapestry of discovery with delivery**
- 2 From exploration to discovery**
Microsystem simulation, translational science,
healthcare advancements, national academy,
obesity intervention, undergraduate research
- 9 From instrumentation to discovery**
nanoHUB, analytical instrumentation, fluid power,
brain injury center, summer research
- 14 From Indiana to the world**
Advanced manufacturing, global collaborations,
history, researchers-in-training, spirituality
and society, cyber security
- 22 From earth to space**
Precious resources, renewable energy, real-time
data, plants in space, acid rain, faculty success,
computational grid
- 27 From funding to discovery**
Record awards, sponsors
- 30 From discovery to delivery**
Technology licenses, Mann Foundation, startups,
tomorrow's innovators, commercialization award

Purdue weaves tapestry of discovery with delivery

Like the warp and weft of a fine tapestry, Purdue University research weaves discovery with delivery to create new fabrics of **UNDERSTANDING, LEARNING** and **OPPORTUNITY**.

The wondrous tapestries of research you'll read about in this report and countless more at Purdue University come from building on the work of earlier researchers, drawing on cross-discipline and multidisciplinary collaborations, and **TAPPING** the **POWER** of **SYNERGY**.



Purdue a hub of innovation, global collaboration

In a ceremony opening the April 2008 Global University Convocation, Purdue students carried flags from more than 120 countries to reflect the university's international reach. Held during the inauguration of President France Córdoba following her summer 2007 arrival, the convocation highlighted the role universities will play in innovation, creativity, and preparing an international workforce for the 21st century.

"We must serve as a hub for global innovation and global collaboration," Córdoba said. "We have the opportunity as never before to link business enterprises to a worldwide network of strategic partners and to ensure our students have global credentials."

Like weavers searching for fibers, textures and colors, then bringing them together in untried combinations to achieve creative milestones, Purdue researchers step into the unknown to explore, question, wonder, try, and ultimately discover.

For basic researchers, those so vital to startling discoveries, the quest may not be for a specific answer. Instead, they seek to understand, to gain new knowledge. While their findings may ultimately lead to practical applications, exploration is their motivation.

Given the time and the tools, a researcher's "I wonder" could indeed become tomorrow's "I understand."

from **EXPLORATION** to **DISCOVERY**

Pioneering microsystem simulating center launched

Lighter, smaller, less expensive, micro-electromechanical systems (MEMS)—machines that combine electronic and mechanical components on a microscopic scale—could open doors of opportunity for an array of civilian and military remote communications, if the devices performed better.

Perfecting such radio-frequency MEMS is the task taken on by the National Nuclear Security Administration (NNSA) Center for Prediction of Reliability, Integrity, and Survivability of Microsystems (PRISM). With \$21 million in funding and 35 researchers, faculty, software professionals and students, it was launched in April 2008 at Purdue University's Birck Nanotechnology Center in Discovery Park.

Focus on behavior, reliability

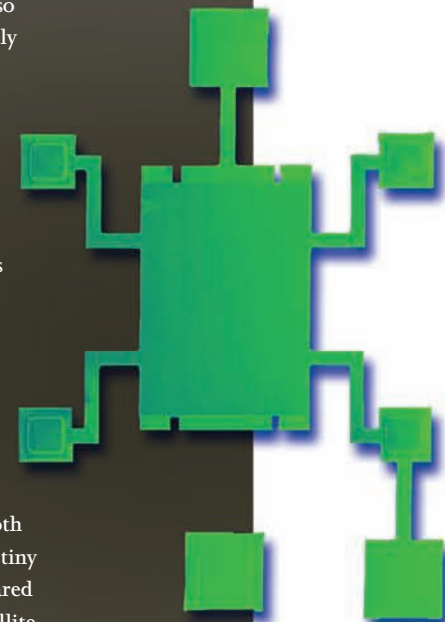
"Before these MEMS devices can be used in critical applications, research is needed to improve their reliability, ruggedness, and durability," says Jayathi Murthy, center director and mechanical engineering professor.

Center researchers will focus on both behavior and reliability of the miniature switches. They must not only

be able to assure that MEMS can withstand gravitational forces, temperature extremes and impact, they must also take into account the fact that matter behaves differently at the nano-scale and that the processes that govern failures can occur over time, from a billionth of a second to several months.

Center personnel are creating simulations that unite sizes and time scales, showing the full workings from the nano-scale to macro-scale features. Then they'll be put to the test. Can they survive after billions of cycles of operation? Can they achieve acceleration/deceleration up to 30,000 g lasting milliseconds? Can they perform under temperatures ranging from -50 C° (-58 degrees Fahrenheit) to 80 C° (176 degrees Fahrenheit)?

Not yet, Murthy says. "But if these failures can be solved, the reasons for them understood, and corrective ways developed, MEMS could be widely used in both defense and civilian applications." Applications for the tiny switching devices, less than a millimeter in size, compared to today's switches of several inches, could include satellite





Purdue University photo/Vincent Walter

communications, weapons deployment, cell phones, automotive sensors, liquid-crystal-display projectors for large screens, and others.

The switches are made of a thin metal membrane located on top of a dielectric contact. During operation, the membrane snaps on top of the contact, altering an electronic property called capacitance and switching off the radio signal and, thus, the device.

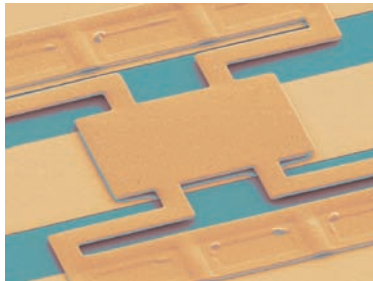
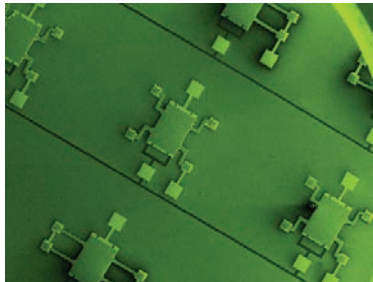
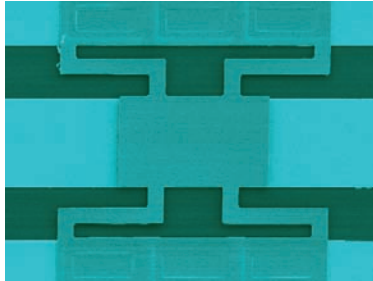
First-ever validation database

Employing the emerging field of predictive science, the center uses computational simulations to predict behavior of complex systems. These will augment published data with validation-quality measurements, creating the first-ever validation database for uncertainty quantifications in microsystems.

“This will enable scientists to make precise statements

Pictured above are some of the researchers working in the NNSA-PRISM project (*back row, from left to right*) Dawn Weisman, Anil Bajaj, Mari-Ellyn Brock, Bob Sayer, Faisel Saied, Wayne Chen, Sanjay Mather, Tim Fisher, Dongbin Xiu; (*front row, from left to right*) Lin Sun, Martin Hunt, Jayathi Murthy, Alina Alexeenko, Dimitri Peroulis.

From **EXPLORATION** to **DISCOVERY**



(top) RF MEMS variable capacitor
over a coplanar waveguide line
(middle) Array of MEMS
variable capacitors
(bottom) RF MEMS Varactor—
the moving membrane
is made of Nickel

about the degree of their confidence in their simulation-based predictions,” Murthy says.

The center’s work includes five thrusts: contact physics, multiscale modeling of structural response, multi-scale aerodynamic damping, uncertainty quantification, and integration of models and numerics. NNSA-PRISM will focus on unclassified applications of interest to the National Nuclear Security Administration and its national laboratories, Lawrence Livermore, Los Alamos, and Sandia.

“Our simulations will make it possible to accurately predict how MEMS devices will stand up to rigor and how long they would last,” Murthy says. “MEMS devices could ultimately replace conventional switches and other electric components. And they have tremendous size, weight, and cost advantages over conventional switches.”

Three universities, many disciplines

The center is tapping the expertise and facilities of Purdue Discovery Park’s Network for Computational Nanotechnology and the Rosen Center for Advanced Computing. “The center takes advantage of Purdue’s interdisciplinary strengths and considerable expertise in computational modeling and

nanotechnology,” says Purdue President France Córdova.

It’s also drawing on the expertise of researchers from materials science, electrical engineering, mechanical engineering, aeronautics and astronautics, math, computer science, and computer architecture.

For large-scale simulations, researchers also have access to unclassified supercomputers operating at the petascale computing level at the National Nuclear Security Administration.

Two universities have partnered with Purdue in the project: the University of Illinois, Urbana-Champaign, and the University of New Mexico. The National Nuclear Security Administration laboratories will also be involved as collaborators and advisors.

Five-year funding includes \$17 million from the Department of Energy’s National Nuclear Security Administration under its Predictive Science Academic Alliance Program; the remaining \$4 million comes from Purdue and its university partners.

Purdue’s is one of just five such centers created. The others are at California Institute of Technology, University of Michigan, Stanford University, and University of Texas at Austin. □

Translational science institute breaks new ground

An unprecedented partnership between Purdue University and Indiana University School of Medicine—the only state-wide program of its kind—began its work in May 2008.

Funded by an initial \$25 million renewable grant from the National Institutes of Health to IU School of Medicine and another \$31 million in university and other contributions, the Indiana Clinical and Translational Science Institute (CTSI)

is improving and accelerating the process for transferring basic science discoveries from the lab to medical treatments and products.

From bench to bedside

“This translational research enables so many things for so many people,” says Connie Weaver, CTSI deputy director and

head of Purdue's Department of Foods and Nutrition. "This is about the most exciting adventure I've participated in at Purdue." She shares leadership duties with IU colleague, Anantha Shekhar, director of CTSI and director of the Neuroscience Clinical Research Center at Indiana University School of Medicine.

Besides the two universities, community partners include Clarian Health, Eli Lilly and Co., BioCrossroads, Cook Group, Roche, Wellpoint, Indiana Economic Development Corp., Indiana Department of Health, and Marion County Health Department.

Seed grants, assistance teams

CTSI will fund competitive seed grants for translational research. Project development teams will review proposals and assign project managers to help move discoveries through additional research and testing. Another team will help physicians implement research findings in their practices. And CTSI will train a new generation of researchers.

"This unique structure means Purdue and Indiana University researchers can address the human health needs of the entire state," says Purdue President France Córdova. "This partnership creates the only national clinic and translational sciences institute that's a statewide research laboratory."

Multidisciplinary effort

The Purdue side of the institute draws on pharmacy, biomedical, veterinary, foods and nutrition, Discovery Park and Purdue Extension. "We're a wonderful complement to IU School of Medicine," Weaver says. "We have so many ideas for discovery, and IU has the clinical experience and disease population to test it. We have Extension, to take it out into the community and say, 'Here's the discovery and here's how to use it,' or we can ask, 'What is your need?' and tell the researchers."

Weaver's own work and lab that performs testing related to Vitamin D absorption and reaction in humans could come into play. "The Department of Foods and Nutrition has a

long history of conducting clinical studies in healthy individuals," she says. "This expertise brings a counterpart to the populations with disease at IU."

Another example is the Weldon School of Biomedical Engineering, says George Wodicka, head. "Our expertise in medical device design, prototyping, and development, including biotechnology approaches, combined with our proven track record in bringing effective products to market, will be invaluable."

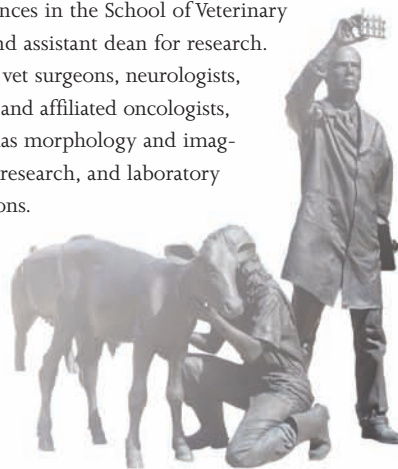
The Medical Discovery Resource Unit (MDRU) in Purdue's School of Veterinary Medicine is another opportunity. "We provide professional expertise and facilities needed to support preclinical and translational biomedical investigation," says John Turek, MDRU director, professor of basic medical sciences in the School of Veterinary Medicine, and assistant dean for research.

Staffed by vet surgeons, neurologists, pathologists and affiliated oncologists, the MDRU has morphology and imaging, clinical research, and laboratory animal sections.

"For a basic researcher to move a concept from the bench to the bedside without a supportive infrastructure would be extremely difficult," Turek says. "The MDRU facilitates the early stages of that process by providing pre-clinical resources to determine if a treatment or therapy is worthy of further development."

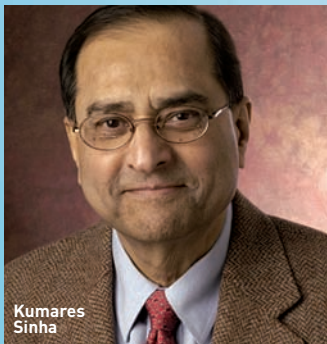


Taking an indirect calorimetry reading from a human subject participant in a foods and nutrition clinical study.



Sinha, Weiner Climb High

Achievements in highway infrastructure engineering and advancements in femto-second optical-pulse shaping technology earned two Purdue professors elite recognition: election to the National Academy of Engineering.



Kumares
Sinha

The two now holding one of the highest distinctions an engineer can attain are Kumares Sinha, the Edgar B. and Hedwig M. Olson Distinguished Professor of Civil Engineering and director of the Purdue/Indiana Joint Transportation Research Program, and Andrew M. Weiner, the Scifres Family Distinguished Professor of Electrical and Computer Engineering.

Sinha's more than three decades of work at Purdue includes engineering, management, and education of transportation professionals.

His research on performance, cost, and optimization are used worldwide in pavement and bridge maintenance, preservation decisions, and safety management systems. "I am humbled by this because recognition comes from my peers," he says.

Weiner came to Purdue in 1992, where he developed technology that creates and controls laser pulses for sensors, communications technologies, and lab instruments. He has been a leader in the lasers and optics field, and holds nine patents. "I feel this work has created something that has been widely useful," he says. □



Andrew M.
Weiner

Energizing, synergizing healthcare research

"One aspect of CTSI is providing technology for healthcare, and also developing new technologies," says Charles Buck, director of operations at Purdue Discovery Park Bindley Bioscience Center and technology liaison for Purdue with CTSI. "Those are some key things we're doing at Purdue. We have a number of case studies we used in our proposal, and we're modeling our activities around them, so we're not starting from scratch.

"The time is ripe for moving forward and assembling all our resources in Indiana to marshal our energy toward improving

healthcare delivery and health in general," he says.

"CTSI is going to energize and synergize existing biomedical research efforts across the state," Turek says. "And investigators will be able to leverage the seed grant funding into additional research dollars." □



Connie Weaver and
Anantha Shekhar

(inset) Connie Weaver CTSI deputy director and head of Purdue's Department of Foods and Nutrition with Anantha Shekhar, director of CTSI and director of the Neuroscience Clinical Research Center at Indiana University School of Medicine at the CTSI Retreat held at Purdue University.



Purdue University photo/Dick Myers-Wells

Stomach to brain: can you hear me now?

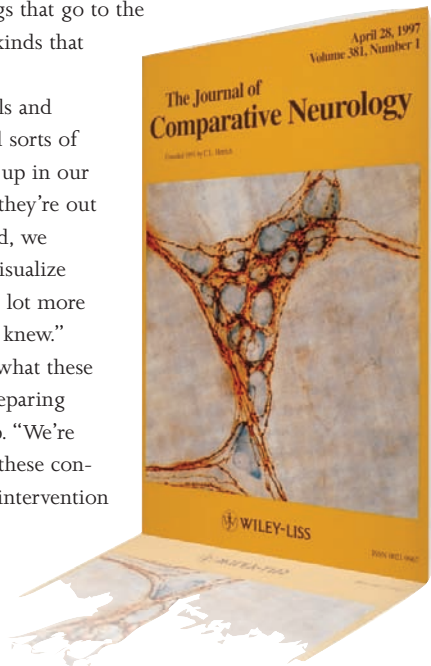
An extensive nerve-ending network channels communications between the stomach and the brain. Listening in on these conversations—and potentially intervening, to reduce obesity—is the goal of Terry Powley, the Ben J. Winer Distinguished Professor of Psychological Sciences.

To further his research, Powley received an \$8.4 million, 10-year National Institutes of Health Method to Extend Research in Time Award from the National Institute of Diabetes and Digestive and Kidney Diseases.

One of just a few selected each year for the award, Powley and his group have already adapted a variety of new and evolving neuro-tracing techniques. “The nerve-ending networks are much more extensive than anyone expected, and much more differentiated,” he says. “There are a number of nerve endings that go to the stomach, and different kinds that return to the brain.

“The brain sees, smells and tastes, but it also gets all sorts of reports that don’t show up in our awareness,” he says. “If they’re out of sight and out of mind, we downplay them. If we visualize them, we begin to see a lot more going on there than we knew.”

Knowing where and what these circuits amount to is preparing Powley for the next step. “We’re beginning to play with these conversations for potential intervention in obesity,” he says. □



From **EXPLORATION** to **DISCOVERY**

NEW GENERATION
OF RESEARCHERS

Undergrads hit the labs

A dozen undergrads interested in engineered interfaces and interfacial processes came from almost an equal number of universities to spend 10 weeks at Purdue during the summer of 2008.

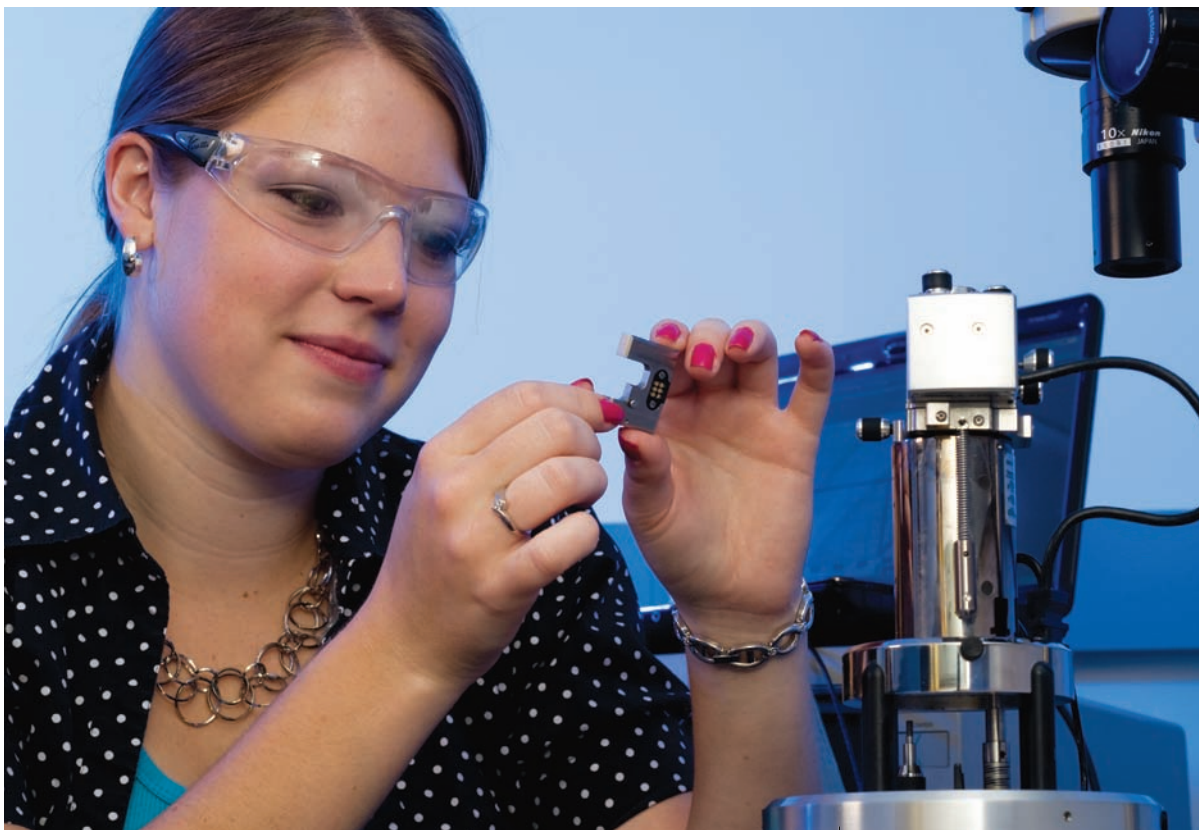
Their goal was to learn about catalysis, fuel cells, biosensing, polymers, nanotubes, drug delivery, and more by working alongside faculty mentors. They chose from research topics such as self-assembly of nanostructured thin films, development of nanostructured catalysts, and novel hydrogen-generating mixtures for portable fuel cells, among others.

The students were participating in a National Science Foundation-funded Research Experience for Undergraduates Program (REU).

"Increasingly, undergraduate students want more opportunities to taste the leading-edge work that goes on in our labs," says Steve Beaudoin, director of Purdue's Design, Application, Analysis, and Control of Interfaces REU Site.

"They did real research in faculty labs, side-by-side our doctoral students. We really pushed them to perform. Students said they enjoyed being able to talk to other students and learn new techniques, and they felt they were part of a true academic culture," he says.

"As a result of this, many will choose grad school," Beaudoin says. "Many will make decisions about what industries they will go to. And they also go back to their classes with a heightened sense of their own abilities." □



Purdue University photo/Vincent Walter

"These research programs enabled me to not only gain valuable job experience, but to understand chemical engineering through hands-on learning and improve my professional skills," says Emily Ellsworth, pictured. The Purdue sophomore participated in both the 2008 Research Experience for Undergraduates and Summer Research Opportunity Program.

With bobbin, shuttle, and loom—some of early design, others incorporating modern advancements—weavers rely on key tools to create innovative results. Researchers, too, count on breakthrough instrumentation and their refinements and enhancements. Today, early scientific instruments—many developed at Purdue—continue to make viable contributions to discovery while new tools are emerging, particularly those capable of analysis at the nano-scale level. What will emerge for use tomorrow is likely already in the concept stage in Purdue's labs.

from INSTRUMENTATION to DISCOVERY

Funding, growth take nanoHUB to new heights

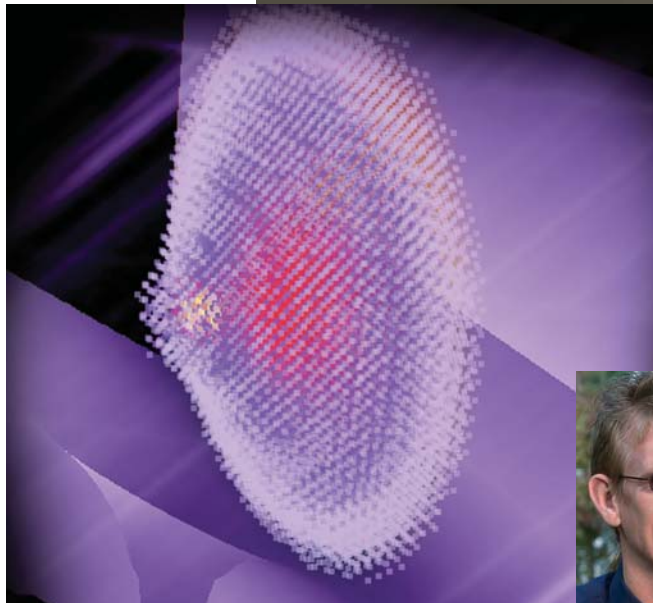
Researchers, teachers, and students the world over are bookmarking www.nanoHUB.org as a first-choice site for nanoscience and technology simulation, information, learning, and exchange. And its rapid growth in resources, users, and funding is making it a cyberinfrastructure model for many more such hubs.

Sharing tools, information

Operated by the Network for Computational Nanotechnology in Discovery Park at Purdue University, which is funded by the National Science Foundation (NSF), nanoHUB is a free, Internet-based science gateway. It uses Purdue clusters, the Open Science Grid, and the high-speed fiber optic Teragrid network, which users tap from ordinary Web browsers on their personal computers. It delivers simulation services, courses, tutorials, seminars, podcasts, user reviews of its tools and content, and opportunities for discussion and global collaborations.

"We have more than 75,000 users a year, up from 1,000 in our debut year, 2002," Gerhard Klimeck reported in early fall 2008. A Purdue professor of electrical and computer engineering, he leads the nanoHUB project. Users include all Top 50 U.S. engineering schools.

By fall 2008, the network's resources totaled more than 1,200, including more than 100 simulation tools, with more continuously being added. Simulation tools aren't

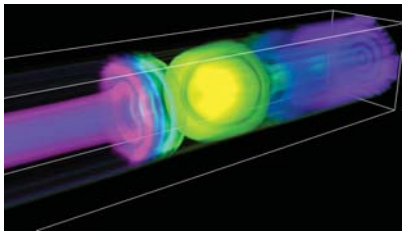


Purdue University image/David Ebert

An international team has identified a new hybrid atom that could be used to develop quantum computers. This data visualization shows an electron density map of the material. The funnel- or vortex-shaped figure in the lower left is an arsenic atom, and the saucer-shaped image in the center is a map of an electron binding to various atoms (each dot represents one location). The yellow dots in the upper left-center are the electron in the quantum state.



Gerhard Klimeck



the batch-mode services common on the Web, Klimeck notes.

"They're intuitive, interactive graphical tools that make it easy for users to learn and explore."

About a third of them deliver results in less than 10 seconds,

and about half in less than a minute.

"Last year, more than 40 classes used the nanoHUB for teaching, and there were more than 265 citations in public literature," Klimeck says.

The nanoHUB also presents opportunities for researchers to share their findings. "As a researcher, this gives me a platform to disseminate my work and convince others that this is useful," Klimeck says. "It's an alternative way of publishing, in a sense. The outcomes are simulation tools, rather than just papers."

Another \$18.5 million in NSF funding

Launched with \$10.5 million from NSF, the network landed another \$18.25 million in NSF funding in fall 2007. Besides creating the cyber-community, meant to be easy to use and accessible, the network's goals are to address key challenges in nano science and technology, develop open-source software, and create unique educational resources. The plan is to engage experimentalists, educators, and professionals in a vibrant, collaborative community, and to inspire and educate the next generation of scientists and engineers.

"This additional funding will help us develop sophisticated new computational tools and disseminate them to researchers, educators, and even industry," says network director Mark Lundstrom, Purdue's Don and Carol Scifres Distinguished Professor of Electrical and Computer Engineering. "With the help of our five partner universities, we are growing beyond our roots in nanoelectronics to new areas such as nanofluidics, nanomedicine, nanophotonics, and applications of nanoscience to the environment, energy, the life sciences, and homeland security."

The partner universities are the University of California at Berkeley, Molecular Foundry at Lawrence Berkeley National Laboratory, University of Illinois at Urbana-Champaign, Norfolk State University, Northwestern University, and University of Texas at El Paso.

Cyberinfrastructure model

"NSF is looking at us to show others how to develop and use cyberinfrastructure like this," Klimeck says. "We have done research in nanoelectronics and other nano areas for 10 years, and we want others to use it. We're focused on making this research useful for others."

Purdue is leveraging the lessons learned and the underlying software infrastructure known as HUBzero to launch other new hubs. Six in completely different disciplines have been launched, and more than a dozen more are in the pipeline.

"As an organization, I would claim we are unique and have the technology to apply to other fields of science," says Klimeck.

Virtual world a viable resource

The nanoHUB's contribution to research efforts around the globe demonstrates its viability and potential.

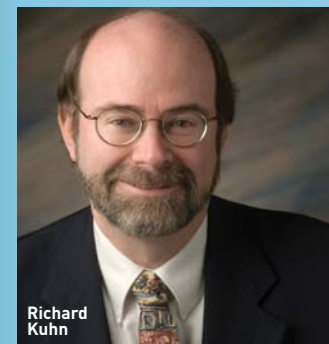
"We will see more and more of this sort of thing for many other types of instruments that are being used around the world," says Arvind Raman, professor of mechanical engineering, citing as an example the nanoHUB resource, Virtual Environment for Dynamic Atomic Force Microscopy (VEDA).

"These are the first Web-based simulation tools of this kind available online," Raman says. "There are a dozen or so research groups around the world with the capability of doing accurate simulations the way we do for dynamic atomic force microscopy, but there are hundreds of researchers who need these tools. This allows researchers to spend more time doing research and less time and money developing simulations." □

Saluting scientific achievements

The spotlight is shining on science research as two faculty earn Herbert Newby McCoy Awards for the year's most significant science contributions at Purdue, and another becomes a Howard Hughes Medical Institute investigator.

Richard Kuhn, professor and head of biological sciences and Gerald and Edna Mann director of Discovery Park's Bindley Bioscience Center, earned distinction for contributions to the molecular and structural understanding of the viral infection process. While he's traveled the world presenting his research, he says, "The award is special because it is a recognition by my Purdue colleagues."

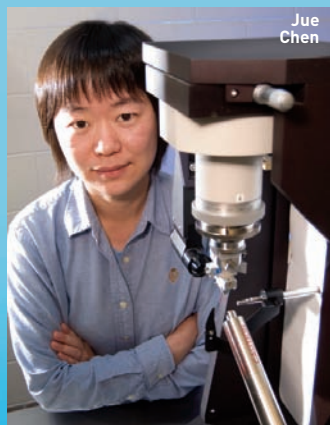


Scott McLuckey, the John A. Leighty Distinguished Professor of Analytical Chemistry, is renowned for developing ion/ion reactions that simplify and



extend mass spectrometry's uses in proteomics. "Part of what makes this award special is it comes from our home institution and relates to a broad cross-section of scientific research at Purdue."

An associate professor of biological sciences and Purdue's first HHMI investigator, Jue Chen solved the structure of the maltose transporter and now studies the drug delivery potential of open-and-close pathways to cells in ABC proteins. She receives a minimum five years' salary and research support. "I'm excited about the new opportunities to broaden my research," she says. □



Innovative instrumentation center opens

The analytical tools of research—vital to measurements and quantitative information in chemistry, biology, and medicine—are getting a 21st century shot in the arm with the 2008 debut of Purdue's Center for Analytical Instrumentation Development (CAID).

Opened in the Bindley Bioscience Center in Purdue's Discovery Park, the center is promising to produce advancements in areas from healthcare to national security.

Cancer its first focus

CAID's first project is building instrumentation to discover, diagnose, and monitor cancer. Future instruments will allow in-the-doctor's-office testing, with results delivered in minutes.

"Advances in instrumentation, such as imaging diagnostics and microscopic methods for analysis, will offer less invasive tests and earlier disease diagnosis," says R. Graham Cooks, the Henry Bohn Hass Distinguished Professor of Chemistry. He co-directs the new center with Fred Regnier, Purdue's John H. Law Distinguished Professor of Chemistry.

Center researchers are working to develop instruments that will allow millions of laboratory samples to be processed in minutes—an overwhelming improvement to what can be done today.

"Current methodologies can't handle the number of analyses that need to be done," Regnier says. "We are facing a future crisis in healthcare testing, and the number of known indicators for disease and routine tests continues to grow. Mass spectrometry and nanosensor-based devices will allow

large-scale clinical analysis to keep up with the rapidly growing number of tests."

Broad applications

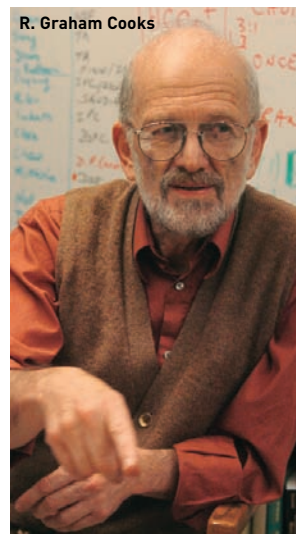
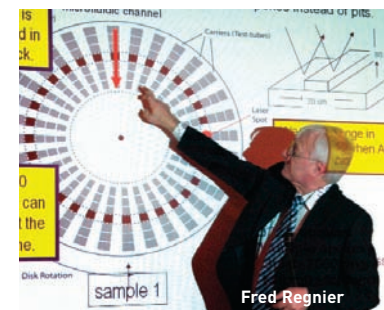
"Instrumentation advances can be applied to diagnosis, disease treatment, technology miniaturization, and security threat detection," Cooks explains. The center is using an existing prototyping program at Purdue to quickly generate and distribute small batches of equipment to test the market.

"Analytical instrumentation underlies much of the research and commercial activity in drug discovery, clinical diagnostics, environmental monitoring, and the fight against chemical and biological terrorism," Regnier says.

Eye on commercialization

An emphasis on entrepreneurship and commercialization—already familiar to both Cooks and Regnier—will move center discoveries to delivery. "It is critical to see advancement through to end products that are available to those who need them," Regnier says.

Regnier's tie to commercial success includes the West Lafayette, Ind., company, Quadraspec. Founded in 2004, Quadraspec licensed Purdue interferometry technology to develop and market a multiplex-capable diagnostics platform.



From **INSTRUMENTATION** to **DISCOVERY**

For Cooks, one link to the commercial world is through his research developments in desorption electrospray ionization (DESI), achieved at the Aston Laboratories of Mass Spectrometry at Purdue. Those developments have been licensed to Prosolia Inc., an Indianapolis company founded in 2003 to develop and market analytical and preparative chemistry tools that enhance and expand the use of mass spectrometers.

DESI can analyze solid samples on a surface with little or no preparation by spraying fast-moving, charged-solvent droplets on the sample. The analytes are extracted from the surface and carried by the splashed, secondary droplets into the atmospheric pressure interface of the mass spectrometer, where ions are produced through the electrospray ionization mechanism.

Building on past developments

The new center's research draws on Regnier's, Cooks' and others' earlier work, as well as some 70 years of past research in the chemistry department.

It is also building on successful models, such as the Jonathan Amy Facility for Chemical Instrumentation established

at Purdue in 1968, the Indiana Instrumentation Institute founded in 2000, and the Indiana Proteomics Consortium, created in 2004.

Collaborative, international work

CAID's collaborations include interactions with chemists, physicists, engineers, geologists, and physicians, and other institutions—University of Illinois, Indiana University, and University of Notre Dame. It's also creating global connections in India, China, South Korea, and Australia.

"Eventually, we hope to not only have researchers from other institutions working in rotating center positions at Purdue, but also to have exchanges and center activities at all the institutions involved," Cooks says.

The potential for this work is so great, Cooks says, "I've given up half my life to it. It's important as an example of what can be done through emphasis on scientific instrumentation and also connections between the regional universities. If those two things work, the lab should serve as a model for others." □

Boosting fluid power

The next generation of fuel-efficient pumps and motors for on- and off-road applications is underway at Purdue's Engineering Research Center for Compact and Efficient Fluid Power. And its discoveries are already landing awards, reports director Monika Ivantysynova, also Maha Professor of Fluid Power Systems in the mechanical engineering and agricultural and biological engineering.

Members of her team landed best paper and five other outstanding awards at the 2008 Fluid Power Net International Ph.D. Symposium in Krakow, Poland.

"We use computer simulation to achieve energy and fuel savings at the component level," Ivantysynova says. "We work on new systems that allow energy recovery, and on hydraulic hybrids, which allow major fuel savings."

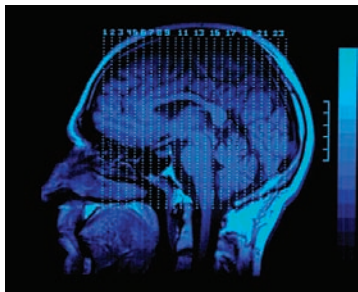
Monika Ivantysynova (*center*), the Purdue Maha Professor of Fluid Power Systems, works in her lab with Edat Kaya (*left*), a lab engineer, and Donnell Cunningham, a student from the Summer Undergraduate Research Program. Ivantysynova, director of the university's MAHA Fluid Power Research Center, has shown how to dramatically improve the efficiency of hydraulic pumps and motors in heavy construction equipment and reduce the machinery's fuel consumption.



Purdue University photo/Vincent Walter

Brain injury center a national resource

A one-of-a-kind research initiative in traumatic brain injury is set to redefine prevention, diagnosis, and treatment, thanks to the expertise of its partners—the colleges of Engineering and Science and the School of Veterinary Science at Purdue, and Indiana University School of Medicine.



From numerical simulation to neuroimaging, pharmacological agent development, clinical treatment, and more, available expertise makes this work a national resource for research and treatment, says James Caruthers, director of the

Center for Impact Science and Engineering and professor of chemical engineering. “We are the only place in the nation with this array of expertise, all available within an hour’s drive.”

The center is one of five centers of excellence under the Purdue Institute for Defense Innovation.

“The signature injury in the Iraq and Afghanistan conflicts is brain trauma,” says Byron Pipes, director of Purdue Institute for Defense Innovation and John L. Bray Distinguished Professor of Engineering. “Some 22 percent of the casualties in these countries are brain injuries, and another 1.5 million to 2.5 million civilians suffer similar injuries every year. Our timing couldn’t be better.”

The research initiative will focus on understanding the physics and physiology of traumatic brain injury, providing a foundation for improving personal and vehicular protective systems, and improving rehabilitation.

“Our strategy is to develop digital models of both animal and human response to these phenomena so minimum testing is required,” Pipes says. □

NEW GENERATION
OF RESEARCHERS

Tackling research challenges

Nearly 40 undergrads from across the U.S. traded summer sun, beaches, and vacations for research, reports, and poster sessions in Purdue’s eight-week, 2008 Summer Research Opportunity Program. The goal: increase the number of talented undergrads from underrepresented social and economic backgrounds who pursue graduate education and research careers.

“Students get an idea of what graduate school is like and gain valuable experience,” says Jon Story, associate dean of the Graduate School and program director. “They also learn about different opportunities they would have with doctorates, and we encourage them to continue their education.”

Research areas included chemical engineering, management, biomedicine, remote sensing, history, early childhood education, and others. Among the topics tackled were hog diseases, cancer research, and attitudinal studies about prejudice.

Each student worked with a faculty member, then prepared a poster to present at the Big Ten’s Committee on Institutional Cooperation’s Summer Research Opportunity Program at Michigan State University.

The program also includes workshops on the Graduate Record Exam, meetings on graduate school topics, and field trips. “The response we get is very positive,” Story says. □



Jon Story (*top*) addressing the students participating in the 2008 Summer Research Opportunity Program.

Gilbert Rochon (*middle left*), director of the Purdue Terrestrial Observatory, works with an undergraduate summer research participant, part of the 2008 Summer Research Opportunity Program.



From the multi-hued, geometric designs of Navajo rugs to the mythologically-inspired kilims of Iran, tapestries have traditionally reflected the characteristics of individual cultures. But what happens when scientists from far-flung areas of the world gather around a single loom, bringing with them their own ideas for addressing a common cause? As researchers tackle such issues as alternative energy, religious freedom, and information security, watch how the weavings change.

from **INDIANA** to the **WORLD**

Advancing Hoosier pocketbooks

From gas turbine engines to luxury RVs, manufacturing represents nearly one-fifth of the state's economy. But for Indiana industries to remain competitive in an increasingly crowded global marketplace, they must learn how to make products faster and better than overseas competitors.

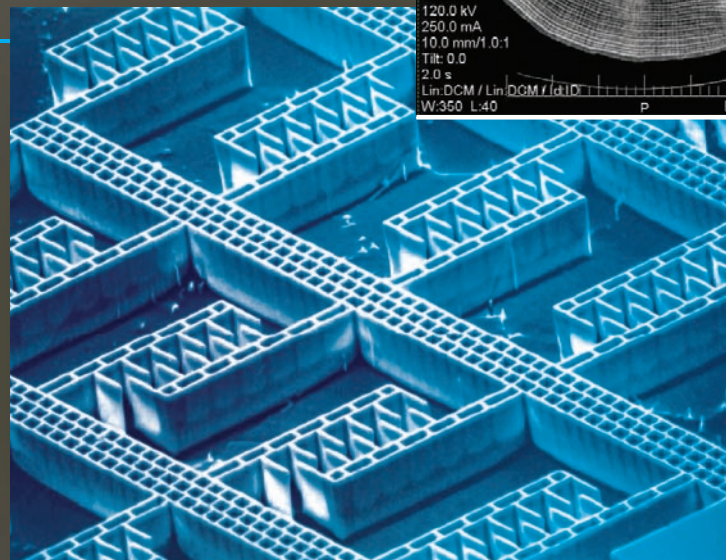
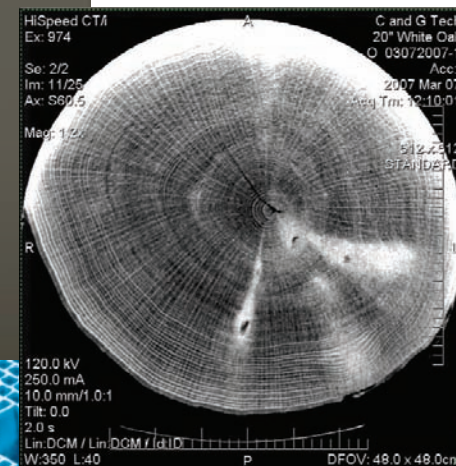
That's the mission of Purdue's Discovery Park Center for Advanced Manufacturing (CAM), which, through research grants and workshops, brings scientists, manufacturers, and employees together to advance the knowledge and use of high-tech applications in industries as wide-ranging as aerospace, medicine, and hardwoods.

Pistons and hip joints

CAM, for instance, is a founding member of the Indiana Advanced Aerospace Manufacturers Alliance, representing the state's 200 aerospace manufacturers, which collectively produce billions of dollars in exports. "Those manufacturers range from big ones like Rolls Royce, ITT Industries, and Raytheon, to small places, machine shops that make parts that go into subassemblies," says John Sullivan, professor of aeronautical and astronautical engineering and director of CAM.

Some of these manufacturers might benefit from the research of Srinivasan Chandrasekar, a professor of industrial engineering who is developing a new, eco-friendly

(above) CAT scan of 20 inch white oak. The scan allows visualization of knots or stressed areas in the wood. (right) Professor Masa Rao's, mechanical engineering, research interest is in the development of titanium micromachining and its application toward biomedical microdevices. He is also pursuing other novel microfabrication technologies. Pictured here is a scanning electron micrograph of a titanium-based MEMS device.



modulated machining system that increases production rates while decreasing the use of energy-hogging coolants. Or Mark Jackson, associate professor of mechanical engineering technology, who is striving to create more precise machines for crafting small, accurate titanium parts.

Surprisingly, the same technology that makes tiny aerospace parts can be applied to medical manufacturing. If you're crafting pistons for airplanes, you want them to last a long time. Likewise, if you're fashioning hip joints, you want them constructed out of material that's not going to wear out. Both require the use of titanium, which is lightweight and incredibly strong, but somewhat difficult to manufacture.

"There are synergies between those two industries," Sullivan says. "You don't have direct competition so they can talk to each other."

In much the same way, aerospace and medical businesses can share the latest techniques in laser-based manufacturing. Airplane manufacturers need lasers to create complex jet engine turbine components that fit well together. Dental companies need lasers for making synthetic teeth that accurately fit a patient's mouth. "The applicability is quite different, but aerospace and biotech are clearly both front and center there as well," Sullivan says.

Precision wood-cutting

Another industry that shares technology with health care is hardwoods manufacturing. Rado Gazo, associate professor industrial engineering, is using CAT scans to visualize the green parts and knots in trees. Placing these into a computer model, he can determine the best way to cut wood before he ever applies a saw. "And if you go further down the line, knowing the grain structure in advance also would allow manufacturers to know exactly what kind of furniture they can make out of that piece," Sullivan says.

Hoosier forests are an \$8 billion natural resource for the state, providing local manufacturers with raw materials for high-end office furniture, recreational vehicles, and luxury watercraft. But far too many trees and byproducts are exported

to far-off destinations—sometimes because of the high cost of manufacturing them here.

"From an economic point of view, adding the value you get from manufacturing products from that hardwood is much more of an economic benefit than just selling hardwood straight out," Sullivan says. "What we don't want to do is take that raw material, ship it to China, then wait for their manufacturers to make something with it and ship it back to us."

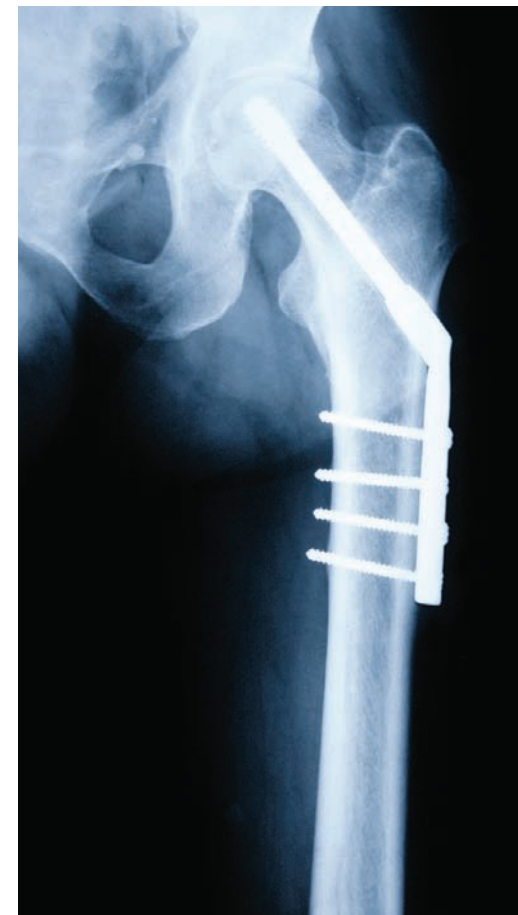
Along with assisting in manufacturing processes, CAM researchers are also investigating hardwood companies' supply chains—how they can combat predicted logging shortages, minimize Emerald Ash Borer damage, and reduce the time that finished products spend in trucks.

Economic security

The results of such research should add up to increased economic sustainability for the state—along with increased prosperity for its citizens. Advanced manufacturing jobs, with the training and degrees required, pay good wages that could help provide new careers to Hoosiers affected by downturns in recreational vehicle and automobile manufacturing, for instance.

But there's a larger payoff as well. Along with advancing the state's and our individual pocket-books, advanced manufacturing can improve our lives through safer airplanes, longer-lasting replacement hips, and fewer pollutants in the skies above. □

Surprisingly, the same technology that makes tiny aerospace parts can be applied to medical manufacturing.



From **INDIANA** to the **WORLD**

Crossing borders



Purdue alum,
Jai Singh (BSME 1949)
and Tim Fisher

As horns honk incessantly in the congested street traffic of Bangalore, India, Tim Fisher is far away in the quiet suburban village of Jakkur, brainstorming with his colleagues on how tiny tubes can spell big changes for automobiles in the future.

The Indian researchers are new members of a cross-cultural, interdisciplinary team tackling energy issues for the likes of General Motors and the U.S. Department of Energy, striving to create affordable hydrogen fuel opportunities. If all goes as planned, 20 years from now hydrogen-fueled cars could represent one-fifth of all automobiles on U.S. highways and beyond.

A hydrogen economy

“Hydrogen storage systems in fuel cell vehicles would replace your gasoline fuel tank,” says Fisher, who, along with doctoral student and NSF fellowship recipient Kyle Smith, spent a five-month sabbatical at Jawaharlal Nehru Centre for Advanced Scientific Research in early 2008. But developing that technology requires the capability of fitting hydrogen—which is actually denser in a solid compound than as a pure liquid—into a storage space small and light enough for a standard sized automobile.

That’s where Fisher and his colleagues can help. They’re investigating how to place hydrogen into nanoparticles and nanotubes, providing enough power to keep motorists on the road for hours.

Speed is also critical. “The particular issue we’re addressing is filling hydrogen tanks fast enough that consumers won’t be put off by having to stand at the pump for a ridiculous amount of time,” says Fisher, a professor of mechanical engineering and a resident faculty member at the Birk Nanotechnology Center.

Those pumps, of course, have yet to be created. As the

United States, India, and other countries pursue alternative energy options, they must also create cross-country infrastructures to support them. But right now, it’s up to engineers, chemists, and physicists to create efficient hydrogen storage options that automobile companies can then apply to the design of vehicles.

By crossing traditional boundaries between nations and disciplines, the researchers may help to engineer a more sustainable future.

Advancing plant science

Back in the states, Rebecca Doerge is also delving into global, interdisciplinary challenges. As a Web cam connects her to colleagues in the Santa Catalina Mountains, the Norfolk

Broads, and beyond, Doerge applies her statistics expertise to issues of plant biology as a member of the The iPlant Collaborative.



Headquartered at the University of Arizona in Tucson, iPlant is an international group of plant biologists, sociologists, statisticians, and information technology professionals. Funded through a \$50 million grant from the National Science Foundation, the program connects scientists virtually and literally to enable conceptual advances in plant knowledge.

“NSF is actually changing how science is done,” says Doerge, a professor of statistics and agronomy and interim head of the Department of Statistics. “The whole idea is to put some kind of computer infrastructure into the study of plant biology. Fundamentally a lot of discoveries in biology

are the same across disciplines. Instead of people working in their silos, iPlant is allowing learning across the whole foundation.”

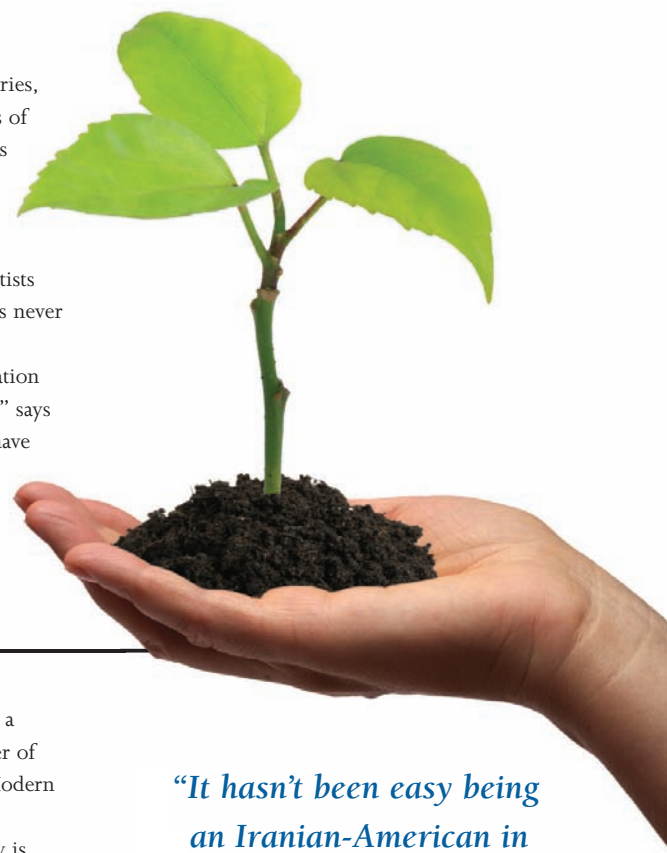
Through on-site workshops in Tucson and research collaborations around the globe, scientists are addressing the most compelling issues facing plant biologists today. Some of those issues are small, such as determining how abiotic stress affects plants. Others are grand, such as mapping every plant gene that exists on Earth.

Ultimately, these collaborations could result in such developments as a computerized map of plant biology. Just as Google Earth viewers can zoom in at images of individual houses, then out to neighborhoods and countries, a plant map would allow scientists worldwide to visualize various levels of plant biology, from the molecular level all the way to complete ecosystems.

That kind of information could lead to new discoveries, such as how tiny changes in carbon and oxygen levels of particular plants affect air quality, or how certain crops fare in different climatic conditions.

Such breakthroughs could enable better decisions on everything from famine prevention to pollution control. Naturally, though, they're dependent on scientists working in a multidisciplinary fashion on a scale that's never been tackled before.

“I think that discoveries will be made from information that already exists but it just hasn't been tied together,” says Doerge. “The people that are evolutionary biologists have not talked to geneticists who actually have been in the field; iPlant puts people at the table together.”□



Iranian history, Los Angeles style

As a professor of history and women's studies, Janet Afary is used to instructing international students. But teaching in classrooms where the majority of her students have Iranian roots is a new experience for her as a fellow with the University of California at Los Angeles.

“Los Angeles has a very large Iranian community; there are tens of bookstores, a number of radio and television stations. It's actually jokingly called Irangeles,” says Afary, the 2008 recipient of the Keddie/Balzan Fellowship awarded by the International Balzan Prize Foundation.

Afary left Iran in the 1980s to attend graduate school at the University of Michigan. Since

joining the Purdue faculty in 1992, she's been named a University Faculty Scholar and has published a number of books, including the forthcoming *Sexual Politics in Modern Iran* (Cambridge University Press, 2009).

This year in California, Afary is rubbing shoulders with a number of prominent researchers in Middle East studies. She's also revising her syllabus to fit the cultural makeup of her classrooms.

“It hasn't been easy being an Iranian-American in the last few years, with a fear of war on the horizon. I want my students to have more pride in their background, to make more sense about the last 30 years of history,” she says.□



Janet Afary

“It hasn't been easy being an Iranian-American in the last few years, with a fear of war on the horizon. I want my students to have more pride in their background, to make more sense about the last 30 years of history.”

—Purdue University professor of history and women's studies, Janet Afary

From **INDIANA** to the **WORLD**

NEW GENERATION
OF RESEARCHERS

World-wise

Last summer, while many college students were flipping burgers back home, 190 undergraduates from around the world were in West Lafayette, tackling such issues as creating better vehicle propellant systems for future space flights and implementing new simulation capabilities on the Purdue nanoHUB.

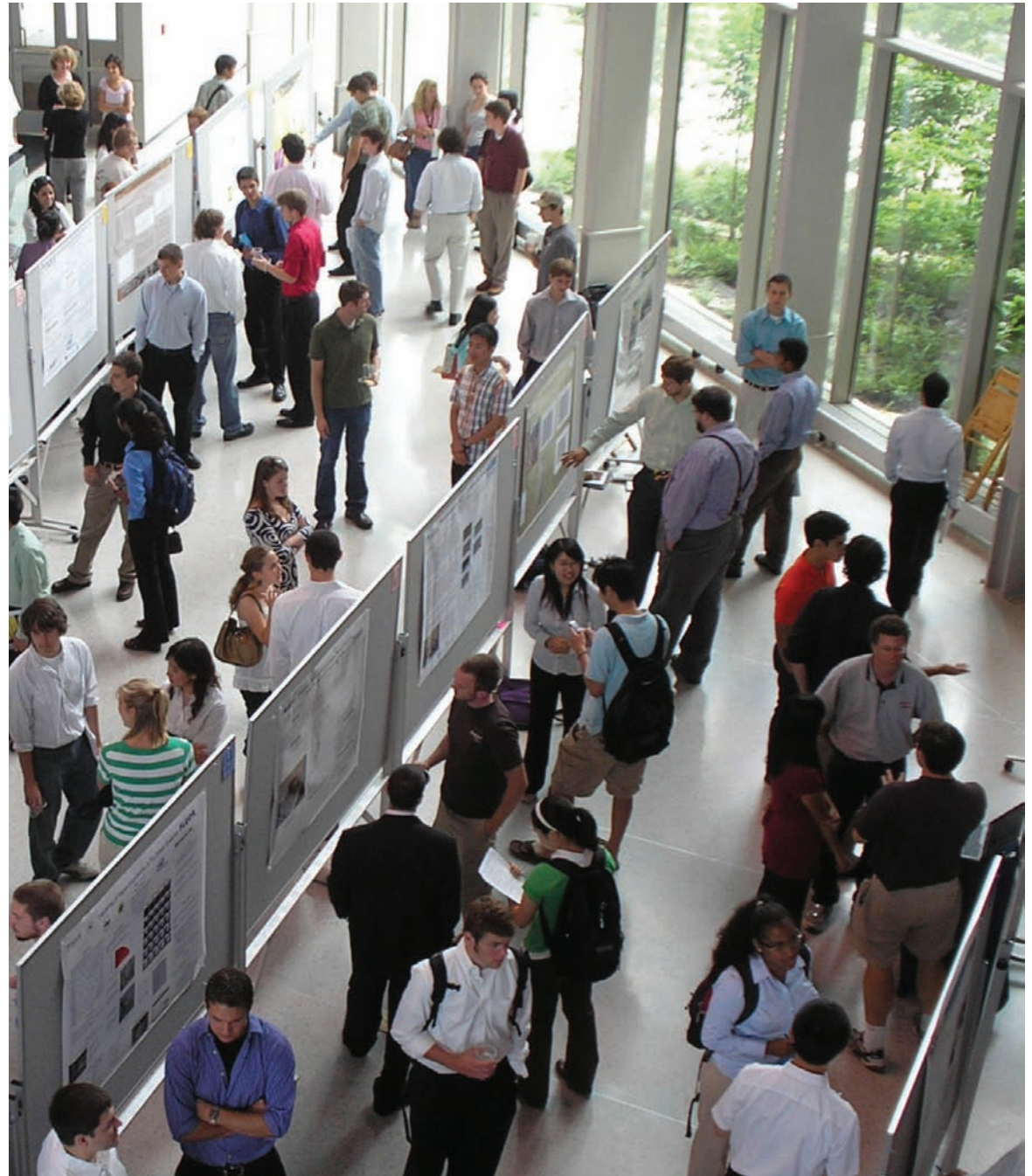
The researchers-in-training—from both U.S. institutions and universities in Finland, Ireland, Mexico, Singapore, and India—were here courtesy of the Summer Undergraduate Research Fellowship,

which teams students with Purdue faculty and graduate students on advanced research projects.

“SURF provides students across all engineering, science, and technology disciplines with an intensive research component not commonly available to undergraduates,” says Melba Crawford, assistant dean for interdisciplinary research in the College of Engineering.

Along with helping to recruit students to graduate school at Purdue, the program also prepares them for the rigors of graduate-level research—designing experiments, collecting and analyzing data, and presenting results. At the end of the summer, students display posters and give oral presentations at a campus symposium.

Domestic and international experiences have long attracted students wanting to broaden their horizons. But especially for undergraduates studying science, technology, engineering, and mathematics, research and work experiences are becoming critical for resumes and graduate-school applications. Says Dan Hirleman, professor and William E. and Florence E. Perry Head of the School of Mechanical Engineering, “There are no regional engineers anymore. If you want to be an engineer in the future, you’re going to become a global engineer.” □





Fenggang Yang

Religion under the radar

Clustered around plastic tables in a crowded McDonald's, dozens of Chinese residents flip open their Bibles, sipping Coca Colas and hoping the police won't break up their peaceful gathering. Such public, but illegal, displays of Christianity are becoming more commonplace in a country hungry for spirituality, says Fenggang Yang, associate professor of sociology and director of Purdue University's new Center on Religion and Chinese Society.

"According to formal regulations, no evangelism is allowed outside the approved church, but that's only on paper," says Yang. "As long as they buy a drink or a hamburger, they own the table at that moment; that's a physical space that becomes available."

China's Cultural Revolution banned all religions. But

since 1979, Protestantism, Catholicism, Buddhism, Taoism, and Islam have been recognized. Now, as the market economy takes hold, more physical gathering spaces are emerging, and individuals are freer to express personal beliefs. As a result, religion has exploded in China—albeit with restrictions.

To understand how religion, economics, and politics intersect in the country, Purdue's new center conducts empirical research, sponsors summits, and trains Chinese researchers. Engaging in religious discussions with Tippecanoe County residents last summer, visiting scholars learned more about a country where proselytizing in fast-food joints isn't inherently illegal. In turn, parishioners discovered more about worshipping in a land where certain discussions outside the sanctuary are still technically forbidden. □



Where privacy and security converge

Last May, just days after the Purdue University Center for Education and Research in Information Assurance and Security celebrated its 10th anniversary, a leading academic report ranked CERIAS as the top program in information security among the nation's universities.

The report, released by Academic Analytics LLC, was based on the productivity of 11 faculty identified with the center.

Considering Purdue's strengths in computer science, electrical and computer engineering, and computer and information technology,

the honor is not surprising. But it's the ability of CERIAS researchers to embrace issues beyond traditional IT domains that really sets it apart.

"Security and privacy of information is not a problem such as someone trying to solve heat buildup in integrated circuits or develop a cure for a particular disease. We're talking about a domain that is much broader than any specific problem," says Eugene Spafford, professor of computer science and CERIAS executive director.

"In addition to treating it as an issue of technology and policy, we treat it as a human

problem, one of education and perception that is grounded in issues of social norms and communication methodologies, even to the very philosophical level of thoughts and privacy." □



Mark Spangler, Jennifer Kurtz and Ed Finkler at a CERIAS symposium poster session

From the floor-to-ceiling windows of a space station, the Earth is a luminous swirl of azure, celadon and white. But zoom into neighborhood view, and like a tapestry, you'll discover the individual threads that comprise the bigger picture.

Last year, our researchers applied their handiwork to such issues as climate change, sustainability in space, and energy conservation. Over time, their craftsmanship will yield grand new designs for challenges facing our planet and the universe. Until then, we can enjoy each new stitch as it comes into view.

from EARTH to SPACE

Precious Resources

Halfway across the world in Anatolia, Turkey, Nicholas Rauh squints through the sunlight into an empty field ahead, scanning the freshly plowed land for remnants of an ancient civilization. Along with his student researchers, he's looking for pottery shards to tell him how the residents of 2,000 years ago lived—and why they left.

Rauh, a professor in the Department of Foreign Languages and Literatures, suspects that a logging economy once thrived in the mountains here, fueling a shipbuilding industry on the coast below.

"The cedar trees that existed were just below the crest of the mountain," says Rauh, who has traveled annually to the region for nearly 20 years. "There are no trees up on top now." Once loggers had laid bare the primordial forest, they likely packed up and left.

Throughout the history of humankind, in fact, villagers have migrated when trees disappeared and rivers dried up. But what do you do when worldwide, resources are being depleted far more quickly than we can replace them?

Power to the people

That's an issue that Kevin Gurney is trying to address.

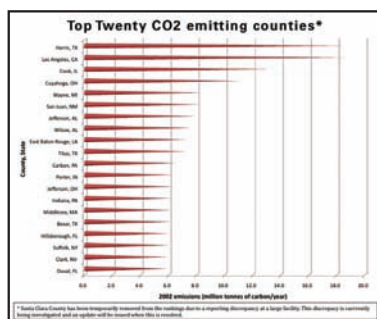
Assistant professor of earth and atmospheric sciences, Gurney is leading a group of scientists in the Vulcan project, which provides high-resolution, interactive U.S. maps showing carbon dioxide emissions.

(top right)
Stone remains
of a Roman-era
lumberjack camp
at 1700 m on
the Tauros moun-
tains. (right)
geology team
extracting soil
samples (carbon
and pollen sam-
ples) from a dried
up ancient lagoon
on the coast.



Instead of employing the traditional method of emissions estimates based on population, the researchers are using more reliable data—actual carbon monoxide and nitrous oxide emissions tracked by the Environmental Protection Agency, the U.S. Department of Energy, and the like.

Now Gurney and his team are employing the same technique to Hestia, a street-level study of Indianapolis pollution. Ultimately, he hopes such information will be made available to the public, so that individual consumers will know how they contribute to the pollution in their own communities.



“This is part of everyone’s everyday lives,” says Gurney, who is also an assistant professor in the Department of Earth and Atmospheric Sciences and the Department of Agronomy. “Instead of blaming other people and being afraid of climate change, we should give people the power and knowledge to help come up with the

solutions, rather than relying solely on the EPA.”

Renewable solutions

Those solutions, naturally, go much farther than easy conservation efforts like purchasing fluorescent bulbs and buying more fuel-efficient combustion engine cars. To find more renewable sources of energy, a multidisciplinary academic community of more than 185 scientists, engineers, political scientists, and economists is collaborating at Purdue’s Energy Center at Discovery Park.

“Crude oil prices reached a record high recently and have shown serious volatility,” says Jay Gore, director of the Energy Center and the Reilly Professor in Combustion Engineering. “Our challenge is to prepare for a transition

from imported fossil fuels to other energy sources and energy independence.”

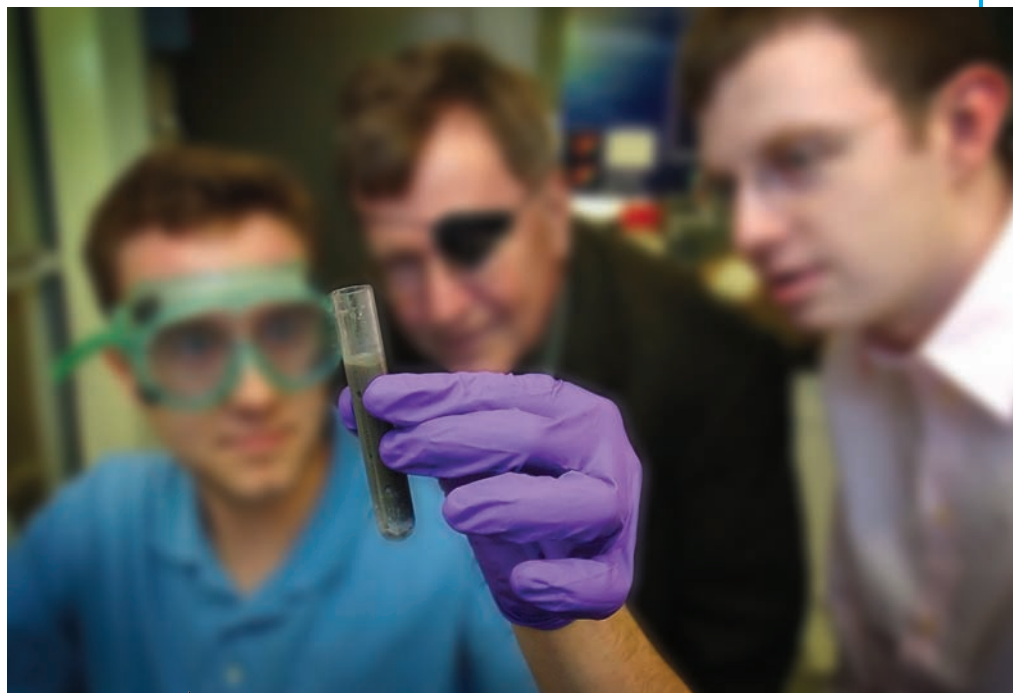
Rather than focus on a single solution for looming petroleum and natural gas shortages, center scientists are investigating a myriad of possibilities.

“We view the energy challenge as something that requires a variety of alternative sources,” says Ron Steuterman, managing director of the Energy Center. “We take the roles of facilitator, catalyst, and relationship broker to introduce people across disciplines. The market will have to choose the solutions.”

Some of those solutions may include cellulosic ethanol, crafted from switchgrass, a summer perennial native to North America, or corn stover, consisting of cornstalks and other waste left in cornfields after harvesting. Especially in Corn Belt states like Indiana, corn stover could be the next big thing in liquefied energy, says Wally Tyner, professor of agricultural economics.

Purdue researchers demonstrate their method for producing hydrogen by adding water to an alloy of aluminum and gallium.

The hydrogen could then be used to run an internal combustion engine. The reaction was discovered by Jerry Woodall, (center), a distinguished professor of electrical and computer engineering. Charles Allen, holding test tube, and Jeffrey Ziebarth, both doctoral students in the School of Electrical and Computer Engineering, are working with Woodall to perfect the process. The technology could, in theory, be used to replace gasoline with non-polluting hydrogen for cars. Initially the method will be used in portable electrical generators.



Purdue News Service photo/David Umbarger

From **EARTH** to **SPACE**

"It is likely that in the next few years cellulose-based ethanol is going to become viable," he says. "With \$6 and higher per bushel corn, it is already very close economically."

Another option is hydrogen fuel. Since President George Bush's announcement in 2003 of a \$1.2 billion hydrogen fuel initiative to develop hydrogen stations across the country by 2020, the U.S. government and private companies have pumped millions of dollars into hydrogen research.

"There is no escaping hydrogen," said Mahdi M. Abu-Omar, professor of chemistry and chair of the Energy Center's Hydrogen Symposium 2008. "We will ultimately get our energy from the sun, and the best renewable source of fuel will be hydrogen produced from water and sunlight." Once researchers solve the problems of hydrogen storage, that renewable resource could become one of the many options for fueling our thriving economies of tomorrow.

A new wave for Lake Michigan

Gazing into the future, George Nnanna envisions on the southwestern shore of Lake Michigan a new wave of manufacturers that slice up silicon for microprocessors.

But the key to attracting computer chip makers is H₂O, he says.

"For every one wafer produced, about 700 gallons of clean water is used," says Nnanna, associate professor of mechanical engineering at Purdue University-Calumet. "That's significant, but the good news is that the water is not wasted." Through careful cleaning, the water can be used again and again.

That's one of the issues being studied by Nnanna and his cohorts at the Calumet Water Institute. Located just south of Hammond's shoreline, the institute aims to help maintain Lake Michigan's water quality by minimizing pollution such as mercury and ammonia. "By so doing, we hope that water can become a catalyst for economic development," says Nnanna, the institute's interim director.

Earlier this year, center scientists completed a study of water-intensive industries. By determining what factors attract such businesses to particular geographic areas, the institute can help local officials sell the region to companies wanting to expand or relocate. "Water is one of the vital natural resources in this region and could potentially be used as an enabler to attract high-tech industries," he says. □



"Water is one of the vital natural resources in this region and could potentially be used as an enabler to attract high-tech business."

—George Nnanna, professor of mechanical engineering at Purdue University-Calumet

Pinpointing disaster

Gilbert Rochon knows firsthand the devastation that a single storm can bring. In 2005, when Lake Pontchartrain swelled beyond its banks, submerging his hometown for days, he mourned the loss of his fellow residents—along with the sudden disappearance of a thriving city.

"Prior to Hurricane Katrina, this region had 40 percent of the offshore oil business, 60 percent of the country's seafood industry, and was one of the top three tourist destinations in the United States," says the former New Orleans resident, whose home was rendered uninhabitable after the disaster. "It's lamentable that we've lost so much of that unique culture of cuisine, architecture, and music."

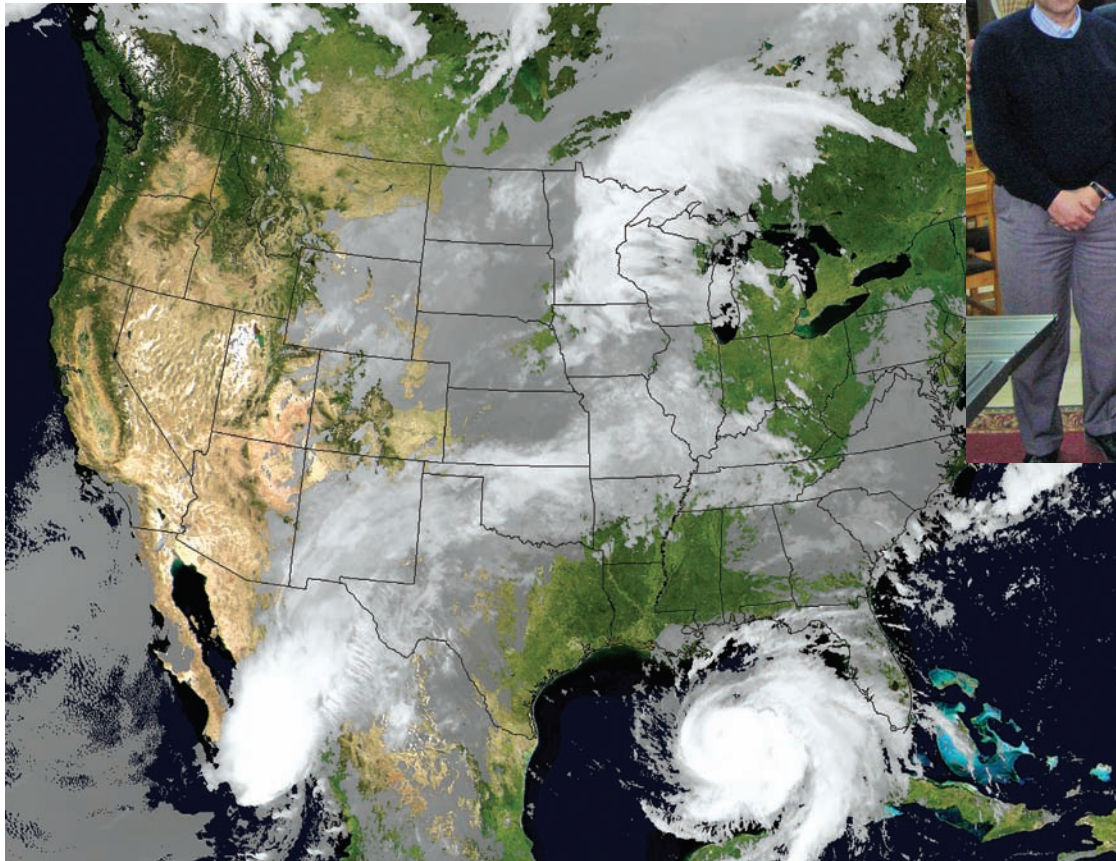
Now, as associate vice president for collaborative research

and engagement with Information Technology at Purdue, Rochon is dedicated to giving scientists and government officials better data for preparing for and responding to natural disasters—whether it's floods in Delphi, Indiana, or mosquito infestations in Cairo, Egypt.

Real-time data

"I'm very sensitive to having technological tools and data sets available," says Rochon, whose chief responsibility lies with the Purdue Terrestrial Observatory (PTO). "By using historical with real-time data, we can then do trend extrapolations as well as predictions."

Some of that historical data comes from the Laboratory



for Applications in Remote Sensing, one of Purdue's oldest research center laboratories. The PTO was created in part to complement the archives of the 42-year-old center by providing real-time information from an array of remote sensing ground-stations.

The PTO groundstations receive data from multiple sensors aboard American and Chinese satellites. Recording at a wide range of spatial resolutions, and comparing that against archived information—from Purdue as well as from NASA, the National Oceanic and Atmospheric Administration, and European, Canadian, Japanese, and Russian satellites—PTO

researchers then can reference and integrate the information into geographic information systems, distributing them by request to researchers and government officials.

When thunderstorms flooded Indiana counties in spring 2008, for instance, observatory scientists compiled visuals on the neighborhoods most affected. Now they're working with the Federal Emergency Management Agency to create 100-year flood plain maps for 820 counties in the United States; the information will allow everyone from homeowners to surveyors to visualize what areas of flat, typically dry land may become saturated during storms.



Hurricane Ike's approach (*left*) to the Gulf Coast was captured by the Purdue Terrestrial Observatory's (PTO) real-time remote sensing GOES geostationary ground station.

(*top*) Pictured are members of a collaborative research team, funded by a grant from the North Atlantic Treaty Organization (NATO) to establish the Kamal Ewida Earth Observatory in Cairo, Egypt, to support early warning and mitigation of disasters and epidemics. (*right to left*) M. Shokr (Canada); M. Abdel Wahab (Egypt); M. Atef, (Egypt); G. Altay, (Turkey); G. Rochon, (Purdue); O. Ersoy, (Purdue); G. Afandi (Egypt).

Bereket Araya, graduate student and research assistant at the PTO, works on Purdue's sub-contract from FEMA to develop 100 year flood plain models for 850 non-coastal counties in the U.S.

Going green (or purple) in space

Bathed in shades of magenta and blue, leaves of a cowpea plant cluster around strips of tiny lights, thriving in Cary Mitchell's indoor horticulture lab without the benefit of sunlight. Thanks to the work of Mitchell and his team, NASA may one day cultivate vegetable gardens in the far reaches of our galaxy.

"Our goal is to change the way that lighting is delivered," says Goia Massa, postdoctoral research associate in the Department of Horticulture and Landscape Architecture. Instead of using hot, bulky, overhead lamps, the scientists are employing LED lights snapped into rectangles of anodized aluminum.

Hanging vertically within a crop canopy, the lightsicles can be turned on or off as needed. Plus, they save power by illuminating only spaces where leaves occur. "They're lightweight and they're not fragile either," says Mitchell, a professor of plant physiology and horticulture. "They're solid state, they last a long time, and they emit only wave-lengths that the plants need, saving energy in yet another way."

Ultimately, that could mean fresh vegetables and fruit for astronauts living on freeze-dried foods. "Even a limited amount of crops such as lettuce, tomato, and strawberries would add antioxidants plus variety to a dehydrated food diet," says Massa. "In an extremely hostile foreign environment like the moon or Mars, a garden also would produce psychological benefits, improve air quality, and even help protect and repair DNA damage from radiation." ■



Early-warning systems

PTO officials also have received a planning grant from NATO's Science for Peace and Security program to develop a comprehensive plan for replicating the terrestrial observatory at Cairo University and at Al Azhar University. Support comes from about \$400,000 in multilateral funding and \$200,000 of in-kind matching funds from Egypt.

Working with the prime minister's office; Egypt's Ministry of Agriculture; World Bank-supported agencies; the World Health Organization; and NARSS, the Egyptian space agency, researchers will set up a tracking station in Giza at Cairo University, along with a geostationary groundstation in Nasr City at Al Azhar University.

"The primary purpose of that project is to build capacity for early warning and mitigation of natural and anthropogenic disasters—flooding, storms, oil and chemical spills," Rochon says.

Naturally, no satellite can predict where a suicide bomber will strike. But terrestrial observatories can create vulnerability assessments, allowing researchers to identify where barriers or surveillance equipment would be best used.

Satellite data specifically will help Egyptian researchers predict crop destruction caused by flooding and desertification of the Nile River. And using archived information, they can monitor infectious disease vector habitats. By watching areas where previous arthropod infestations have occurred, scientists can look for signs of rapid green-up and surface water availability—conditions needed for dormant eggs to hatch.

"That's an area where you can then deploy early warning systems, using inexpensive larvicides rather than waiting for the insects to mature and using more expensive insecticides that are deleterious to benign species," he says.

That, in turn, may help to minimize the risk of famine when crop shortages occur. "There's a synergistic relationship between malnutrition and infection, as discovered by researchers Scrimshaw, Taylor, and Gordon back in the 1960s; those who are infected with some diseases are more likely to become malnourished and vice versa," Rochon says. "Knowing these connections and monitoring them will help officials monitor local food stores so that, if necessary, the international community can respond before you get to the point of having pictures on television of hungry babies." □

ADVANCE Purdue leadership meeting, (left to right), Klod Kokini, associate dean for academic affairs, College of Engineering; Alice Pawley, professor of engineering education; Barb Clark director of women in science program and science diversity office, special assistant to the provost; Chris Sahley, associate dean College of Science, and Linda Mason, professor entomology.

Searching for heroines

The development of family-friendly vans, windshield wipers, and filtered coffees all relied on the genius of women as well as men. Yet despite these innovations, too few females have followed in their footsteps.

But to recruit more women into STEM fields of study—science, technology, engineering, and mathematics—universities must increase the number and diversity of women in STEM faculty positions.

That's the premise behind a \$3.92 million National Science Foundation grant announced earlier this year at Purdue University. The Purdue ADVANCE Institutional Transformation project will establish the Purdue Center for Faculty Success that will help enhance recruitment and retention of women.



Purdue University photo/John Underwood

Cleaning acid rain

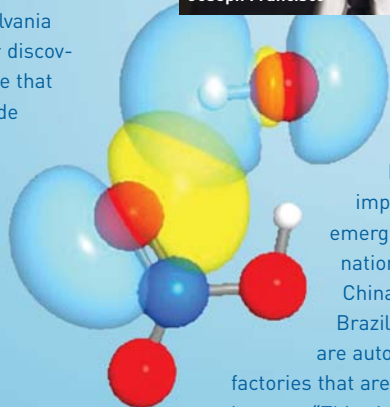
For 40 years atmospheric scientists have peered into the sky, wondering how clouds break down pollutants emitted by automobiles and factories. Thanks to the efforts of Joseph Francisco, they now have their answer.

Earlier this year, Francisco and a colleague at the University of Pennsylvania announced their discovery of a molecule that cleans nitric oxide and other compounds causing acid rain. A cluster of nitrogen, oxygen, and hydrogen enables the atmosphere to oxidize these compounds, which routinely belch out of smokestacks and exhaust pipes.

Francisco, the William H. Moore Distinguished Professor of Chemistry and the 2007 recipient of Purdue's Herbert Newby McCoy Award, says that now, scientists can better understand how pollutants react in the atmosphere, allowing them to predict potential outcomes.



Joseph Francisco



"This becomes important in emerging industrial nations such as China, India, and Brazil where there are automobiles and factories that are unregulated," he says. "This chemistry will give us insight into the extent that acid rain will be a future concern."

Francisco has been named president-elect of the American Chemical Society (ACS). He will serve in this position during 2009, becoming president of ACS in January 2010. □

"This effort will provide the role models to encourage more young women to enter these fields and succeed," says Purdue President France Córdova. "It is essential that more of our domestic students prepare for and enter STEM disciplines and agriculture. These fields are key to global competitiveness."

A related NSF grant is focusing on how early-elementary experiences shape career decisions among girls. Brenda Capobianco, associate professor of science education in the Department of Curriculum and Instruction, has received a three-year, \$449,000 grant to examine engineering perceptions, aspirations, and identity among first through fifth graders.

"Our primary goal is to learn how girls approach, experience, and interact with engineering activities and how their learning informs who they think they are and who they want to be," says Capobianco. Once researchers know better how to attract young girls to the field, then hopefully by the time they enter college, there will be more heroines to guide them toward their goals. □

Lafayette, Purdue University Calumet, and the University of Notre Dame.

"At its most fundamental, the grid is enabling new collaborations," says Gerry McCartney, Purdue's vice president for information technology and chief information officer. "But it's also allowing us to do science in ways we haven't before. It's not just that Calumet and Notre Dame can use our high-performance equipment, but that using the grid is bigger than adding the three parts together."

Computational grids like NWIC operate on this principle of synergy, linking computers through a network to process jobs too big even for a supercomputer. Already, the NWIC is allowing researchers like Robert Kramer, director of the Energy Efficiency and Reliability Center at Purdue Calumet, to tackle the issue of electricity delivery and reliability.

Skyrocketing energy costs and a looming energy shortage threaten the nation's and the region's economy. Because the NWIC is located at the intersection of two major electrical grids—the Midwest Independent Transmission System Operator, Inc. and PJM Interconnection—it potentially can serve as an independent communication link, providing real and simulated electrical transmission load calculations.

That information could help improve the capacity of current electrical grids and reduce expensive, potentially unnecessary infrastructure investments in the future. □

Super cyberstructures

Tackling society's grand challenges requires more than human brainpower. It also requires the superpower of distributed computing facilities, like the new Northwest Indiana Computational Grid now linking Purdue University West

While each step in the research process is key, like the weaver's loom, funding is the foundation. This year, Purdue proposals were enthusiastically endorsed by governments and industries, many at unprecedented levels, to help researchers initiate and continue work leading to new discoveries.

from FUNDING to DISCOVERY

Record sponsored funding

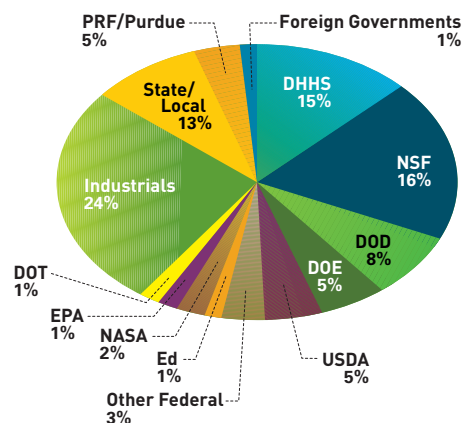
A new level of breadth and depth of exploration in multiple arenas, and unparalleled collaborations on campus and internationally create a distinctive research pattern at Purdue University.

Funding achieves high mark

Purdue University's entrepreneurial faculty, strategic partnerships and multidisciplinary collaborations all played key roles in setting a new record of \$333.4 million in sponsored research in 2007/2008. The total is up a significant 11 percent from the year before.

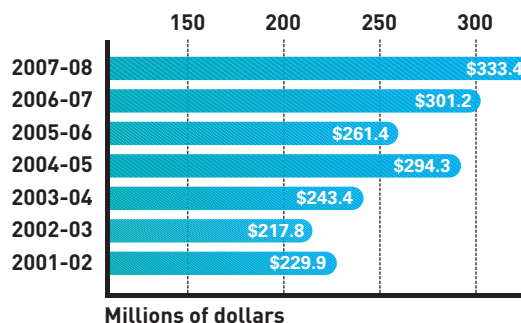
Hundreds support Purdue research, FY 2007-2008

From private industry to state, local, national and foreign governments, hundreds of funding sources support Purdue researchers.



Awards top \$333 million

Purdue University generated a record \$333.4 million in sponsored research funding during the 2007-08 fiscal year, up 11 percent from the previous year.



Row after row, weavers advance the warp, creating the useful and the decorative to better and enhance others' lives. Similarly, researchers move from discovery to delivery, transferring new knowledge, processes, systems, and products to commercial opportunities that enrich lives, communities and the world.

Purdue Research Foundation's Office of Technology Commercialization—the conduit for moving discoveries from research labs to the real world—achieved dramatic successes in 2007/2008, demonstrating the value of university research in our world's advancements. And educational opportunities opened the doors of the entrepreneurial world to students.

from **DISCOVERY** to **DELIVERY**

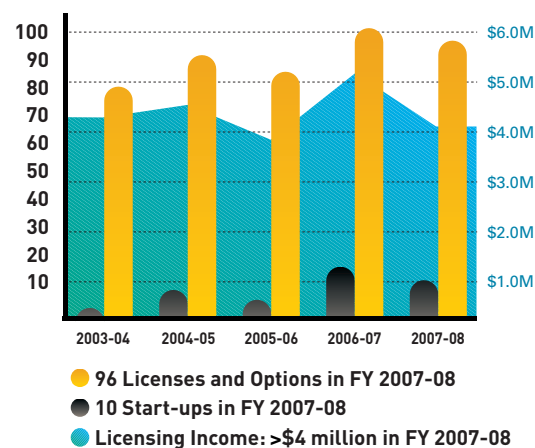
Feeding the commercialization pipeline

"We experienced exceptional growth in moving inventions to the market," reports Karen White, acting director of the Office of Technology Commercialization.

"While these are impressive numbers, the real story is the impact on human lives, medical advances, crop improvements, and business opportunities," says Joseph Hornett, Purdue Research Foundation's senior vice president, treasurer, and chief operating officer. "What happens in the labs and research centers at Purdue positively impacts lives and our world in a myriad of ways."

This completes the cycle that begins with research funding. With licensing, Purdue's discoveries are delivered to the world.

Robust activity marked the 2007/2008 year in the Office of Technology Commercialization:



Accelerating drug delivery

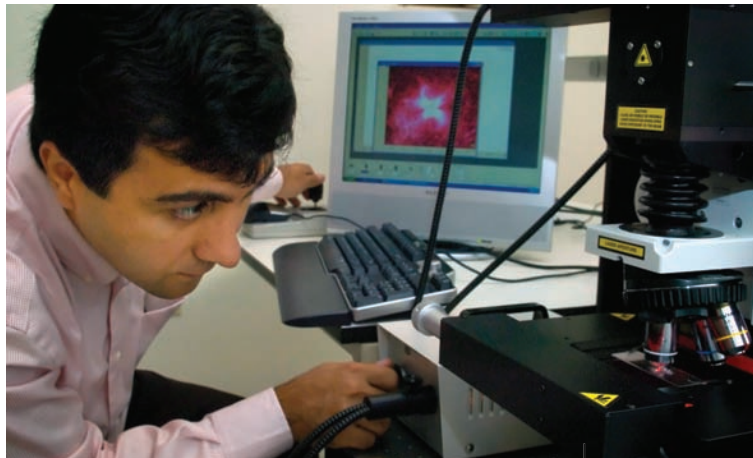
When patients need to fill prescriptions in a hurry, a drugstore is usually just minutes down the road. But for researchers developing breakthrough treatments in their laboratories, the trip to the pharmacy may be years away.

Thanks to the Mann Foundation for Biomedical Engineering, a few promising Indiana products may find a shortcut to market in the future.

In 2007, the foundation established the Alfred Mann Institute for Biomedical Development to enable companies to commercialize innovative technologies that improve human health.

Discovery, of course, is only one step in the commercialization process. After filing for patents, researchers must secure funding, locate or create a manufacturing facility, and develop a distribution system for reaching end-users. Monies from the institute will help accelerate this process for a few choice projects each year, with preferential treatment being given to Indiana companies.

Alfred Mann, a medical device entrepreneur and prominent philanthropist, said he wants to bridge relationships between academia and industry, speeding the delivery of health-related products to physicians and their patients. "The University's proven track record of interdisciplinary research and its extraordinary academic leadership and entrepreneurial spirit were key in its selection for this partnership," said Mann. □



Creating tomorrow's innovators

Whether it's the next Yahoo or Facebook, many twenty-somethings dream of pursuing their own paths, bypassing the climb up the corporate ladder. But while the thought of entrepreneurship may attract many young college grads, for all but a few lucky and talented individuals, the opportunity to start a new venture often comes later in life.

That's why Purdue University focuses on long-term leadership potential in its five-course Certificate in Entrepreneurship and Innovation program.

"The objective of the program is to make entrepreneurship an accessible career choice for students," says Nathalie Duval-Couetil, program director and associate director for the Burton D. Morgan Center for Entrepreneurship in Discovery Park. "We help them develop leadership and communication skills, show them how to research products and their potential, and really seek to enhance their performance and marketability within their disciplines."

According to the U.S. Department of Labor Statistics, the average person born in the later years of the Baby Boom held 10.8 jobs from age 18 to age 42. That's a far cry from a not-so-distant past, when lifetime employment was almost guaranteed.

Today, some professionals view entrepreneurship, and the ability to create their own jobs, as a more stable employment option than traditional corporate employment.

"We help them develop leadership and communication skills, show them how to research products and their potential, and really seek to enhance their performance and marketability within their disciplines."

—Nathalie Duval-Couetil, program director and associate director for the Burton D. Morgan Center for Entrepreneurship in Discovery Park.

Purdue Weldon School of Biomedical Engineering associate professor Ozan Akkus conducts research on crystals such as mono-sodium urate and calcium pyrophosphate dihydrate. These crystals can accumulate in the synovial fluid and lead to gout, which results in severe inflammation and arthritis in joint spaces. This research could help improve diagnosis of the crystal species in synovial fluid samples. The research is just one example of biomedical engineering research conducted at Purdue.

From **DISCOVERY** to **DELIVERY**

2007-08 STARTUPS

Ten new companies from the east coast to west were founded to take discoveries to the next step.

» Energy

- + **GreenTech America Inc.**, Purdue Research Park, headed by chemical engineering research professor Nancy Ho, is commercializing a yeast-based cellulosic ethanol technology.

» Food

- + Using work by horticulture and landscaping architecture professor Ray Bressan, California-based **D-Helix** is developing disease-resistant and drought-tolerant plant genetics.
- + **Dynamic Polyol Co.**, Washington, is producing artificial sweeteners and other ingredients; and **Intelliphage Inc.**, Purdue Research Park, is commercializing pathogen-detection devices developed by food science associate professor Bruce Applegate.

» Health

- + Small-molecule, anti-cancer therapeutics are the focus at Indianapolis, Ind.'s **Apex Therapeutics**, founded by pharmaceutical professor Richard Borch and Indiana University School of Medicine professor Mark Kelly.
- + Fiber-based delivery systems for colonic health, using food science professor Bruce Hamaker's findings, are the products at **Nutrabiotix LLC**, Purdue Research Park.

» High-tech

Four companies have licensed computer applications:

- + **Imaginestics LLC**, Purdue Research Park, uses mechanical engineering professor Karthik Ramani's software that recognizes visual images when searching online for product suppliers.
- + **Knight Mechanical Testing** in Fort Wayne, Ind., is a contract test lab using research by biomedical engineering associate professor Eric Nauman.
- + Civil engineering research scientist Bobby McCullough is using his work in a software and consulting business, **McCullough Consulting**.
- + **NanoG LLC**, Connecticut, is tapping chemical engineering associate professor Hugh Hillhouse's work to develop nano-based products. □





(opposite page) RJ Pate presents a new business venture developed by a student team as part of the Certificate in Entrepreneurship and Innovation Capstone course.

The Certificate Program Entrepreneurship Capstone course is led each semester by a practicing entrepreneur or venture capitalist.

Some may find entrepreneurial opportunities with current employers—helping to develop a new biomedical product line, for instance, or opening a new sales office in Singapore. Others may join tomorrow's startups, while even others may start their own businesses.

To make sure students are prepared to take a leap when a high-growth opportunity comes along, instructors discuss how to conduct market research, perform a financial analysis, and write a business plan—preferably not one focused on on-campus businesses like textbook sales, but on ventures that would be viable beyond the University.

As students learn the steps to entrepreneurial success, they also discover technology commercialization opportunities at the Purdue Research Park and various incubators throughout the state. Says Duval-Couetil, "Many students can spend four years on this campus and never know where Discovery Park is, let alone what Purdue Research Park does." By the time students earn their certificates, they'll know how Purdue and the state of Indiana can help them develop their own companies—whether that's five, ten, or twenty years from now.□

Hats off to inventors

When disaster strikes, it would be good to know how governments, companies, organizations, and the public would respond. It would be even better to know how to improve that response, especially for world peace. That's one application, along with business economic models, of a decade's research at Purdue University by Alok Chaturvedi, Krannert School of Management professor and founder and former director of Purdue Homeland Security Institute.

For creating synthetic environments for analysis and simulation technology that can be used on any platform, Chaturvedi—also president and chief executive officer of Simulex Inc., which commercialized his research—received Central Indiana Corporate



Alok Chaturvedi

Partnership's Outstanding Commercialization Award in fall 2007.

"He's a perfect example of a Purdue researcher who uses his knowledge and expertise to help others," says Joseph Hornett, senior vice president, treasurer, and chief operating officer of Purdue Research Foundation, which hosted the awards event.

Chaturvedi was one of 29 Purdue faculty and staff inventors honored for discoveries with potential commercial applications benefitting society. Fields represented included agriculture, engineering, foods and nutrition, pharmacy, science, veterinary medicine, and visual and performing arts.□



Today, you'll find rich tapestries in every texture, color, and field. Purdue's powerhouse research includes technological advancements, instrumentation developments, scientific breakthroughs, new comprehensions of the human mind, medical achievements and more. Research is the focus of undergraduates, graduate students and distinguished professors, all working together to deliver solutions to today's grand and global challenges.



**PURDUE
ACHIEVES
LEGACY OF
DISCOVERY,
DELIVERY**

“The synergies sparked by multidisciplinary research at Purdue University create an environment for discovery leading to transformational innovations that have the potential to solve some of our world’s grand challenges.”

—Richard Buckius, vice president
for research

2007:2008 Office of the Vice President for Research
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