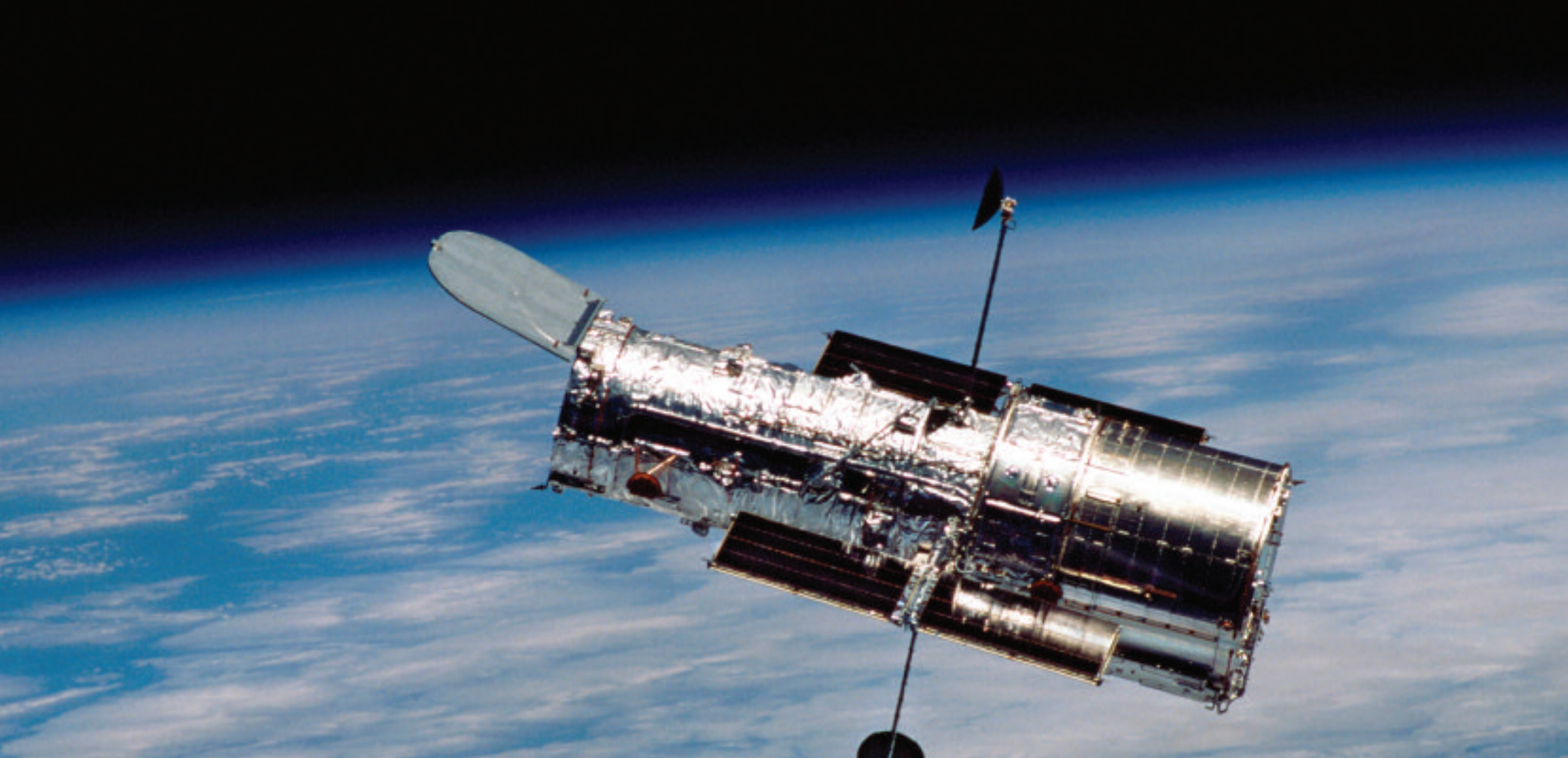


2008:2009
Office of the Vice President
for Research Annual Report

ADVANCING *the* FRONTIERS of KNOWLEDGE
and DELIVERING INNOVATIVE SOLUTIONS



PURDUE
UNIVERSITY



(cover) Star birthing region in the Orion Nebula. *(this page)* NASA Hubble Space Telescope orbiting Earth. *(insets left to right)* Images from Hubble of infant stars in the small magellanic cloud; the gaseous outer layers of a Sun-like star glow in space after being expelled as the star reached the end of its life; Great Orion Nebula, with more than 3,000 visible stars; Whirlpool Galaxy M51.

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Purdue is advancing the frontiers of knowledge and delivering innovative solutions.

The breadth and depth of research at Purdue University spans virtually every field, from nanoscale studies to the vastness of space, from the seen to the unseen, from that just beginning to be understood to the stark unknown, and from the study of animals and humans to their health and behaviors.

Purdue University is the birthplace of stars who are discovering new worlds of possibility. It's a hub of activities focusing on planet Earth, its sustainability and its people. It's launching new scholars. And it's delivering new innovations to the public.

Step into our universe and experience our discoveries.

Images from Hubble Telescope Reflect Our Vision

Imagine what you might see from the NASA Hubble Space Telescope, as Purdue graduate and astronaut Andrew Feustel did when he traveled on NASA's historic STS-125 repair mission in early 2009. You'll get some idea from the images in this report, transmitted from Hubble since its 1990 launch.

Copies of five limited-edition prints now hang in Purdue's Beering Hall of Liberal Arts and Education. They were a gift in 2008 from 1968 College of Education alumna Margaretha Motes McBride, former director of the Muncie Community Schools Planetarium.

These images portray the vastness of our universe, a metaphor for the possibilities prompted by research at Purdue University.

DISCOVERING NEW WORLDS OF POSSIBILITY *Purdue University is a hub of discovery, from advances in particle physics to mimivirus, nanotechnologies, and the solar economy.*

With an appreciation for those who came before us—from Charles Darwin, born 200 years ago, whose species-of-life theory of evolution unifies all life science studies—to Georges Lemaître, whose 1927 big-bang origin of the universe theory inspires us still, Purdue researchers are leveraging early understandings while discovering new knowledge.

We're inspired, too, by the pioneering walk on the moon 40 years ago by Purdue alumnus Neil Armstrong and the success of another 22 Purdue graduates who have donned astronaut suits.

From science to space, microscope to telescope, Purdue University is indeed the birthplace of stars.

BIRTHPLACE *of* STARS

Popping the question

Why does the universe have mass? What is dark matter made of? Do extra dimensions of space really exist?

For centuries, physicists and philosophers have pondered similar questions. Now, thanks in part to Ian Shipsey and Daniela Bortoletto, they may have their answer someday.

In 2008, Shipsey and Bortoletto finished an eight-year project building a pixel detector—a massive digital camera—to operate within the Large Hadron Collider (LHC) at CERN (the European Organization for Nuclear Research).

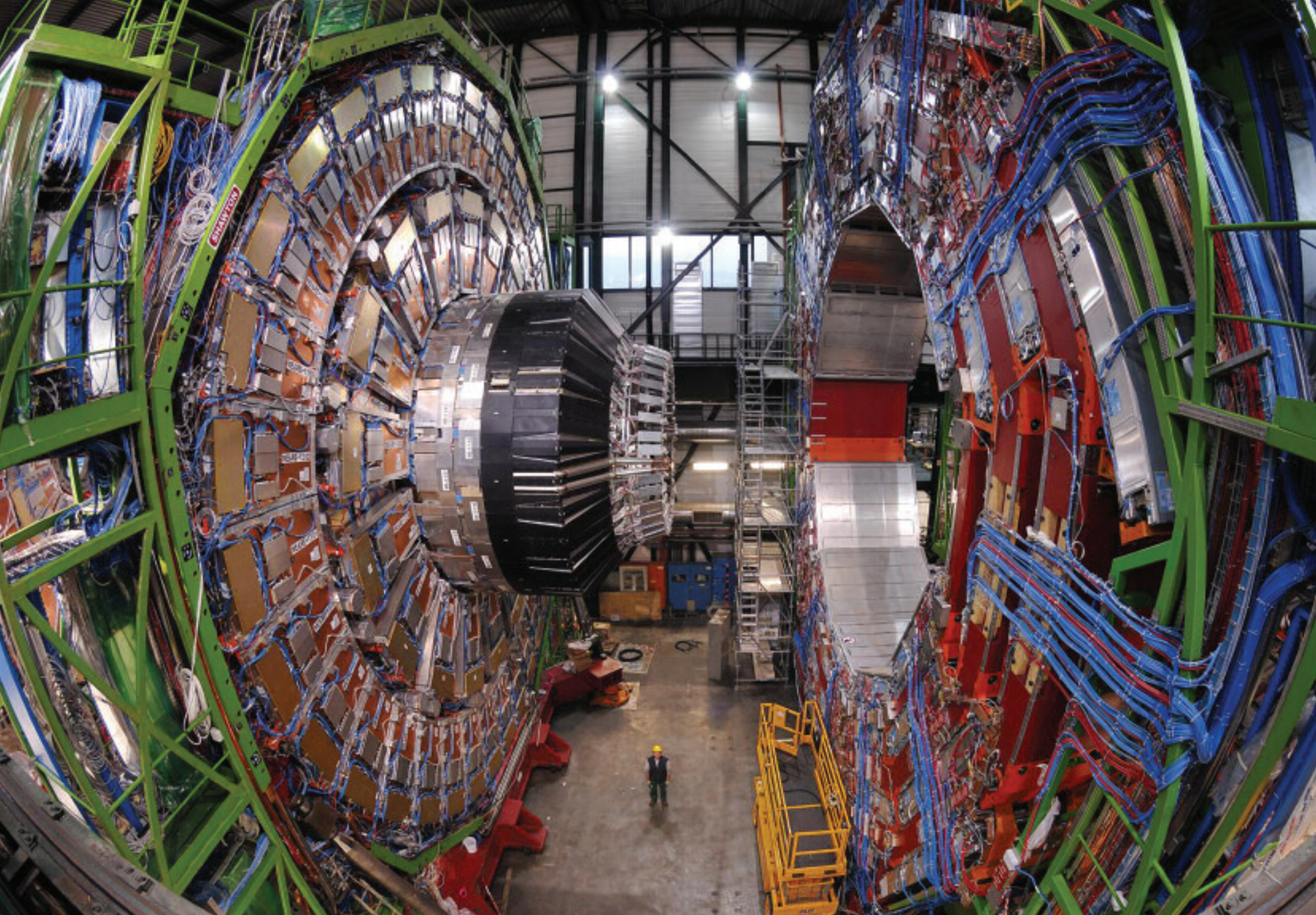
Shortly after the camera was assembled inside the collider's Compact Muon Solenoid (CMS), CERN researchers located 100 meters below the Switzerland-France border conducted their first successful experiment circulating protons at just under the speed of light. Once the scientists perfect their technique of smashing protons together inside the 27-kilometer concrete tunnel, the collisions are expected to produce new particles, generating data for a number of experiments.

(continued on page 5)

Purdue undergraduate students Emily Grace and Brian Kozak help build a camera that may soon glimpse dark matter, the formation of black holes and Higgs particles at the Large Hadron Collider at CERN, the European Laboratory for Particle Physics, in Geneva, Switzerland.

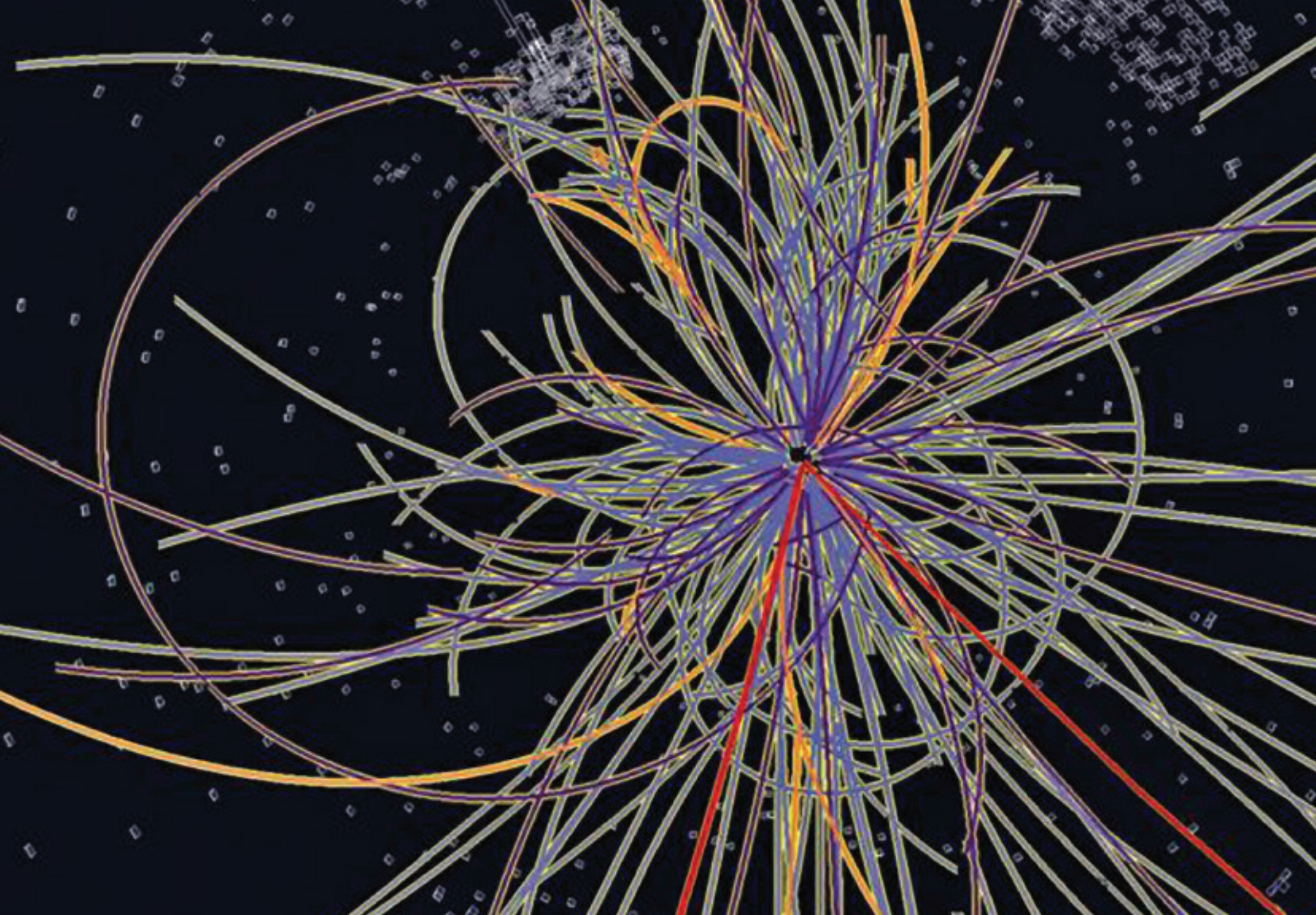


News Service photograph/David Umberger



View of the CMS detector in the surface hall at Cessy.

photo provided by David Miller



A simulated event depicting the decay of a Higgs particle following a collision of two protons in the CMS experiment.



Team members involved in CMS and the construction of the pixel detector at Purdue: (front row, from left) Jason Ortiz, Yu Zheng, Daniela Bortoletto, Ian Shipsey, Emily Grace, Aaron Parrish; (back row, from left) Ozhan Koybasi, Lee Coates, Kirk Arndt, Alan Lichti, Matt Triano, Joe Clampitt, Aaron Parrish.

Quick and precise

That's where the CMS comes into play. As tall as a six-story office building and weighing 14,500 tons, the CMS houses a magnet boasting as much iron as the Eiffel Tower.

"Although 'C' stands for compact, everything about the CMS is large," says Shipsey, the Julian Schwinger Distinguished Professor of Physics. "CMS, much like a Russian doll, consists of a nested set of different types of cameras."

Purdue's pixel detector lies at the heart of the instrument. "A pixel detector functions similarly to a digital camera from the store—except that in our camera, there are 66 million pixels, and the total area covered by our detector is one square meter," says Bortoletto, Distinguished Professor of Physics. "We use a highly segmented detector since we want to take very precise pictures of the LHC interactions."

And very rapid pictures as well; every 25 nano-seconds, the clockwise and counterclockwise beams interact, and the camera must record each of these interactions within the particle accelerator.

A unifying goal

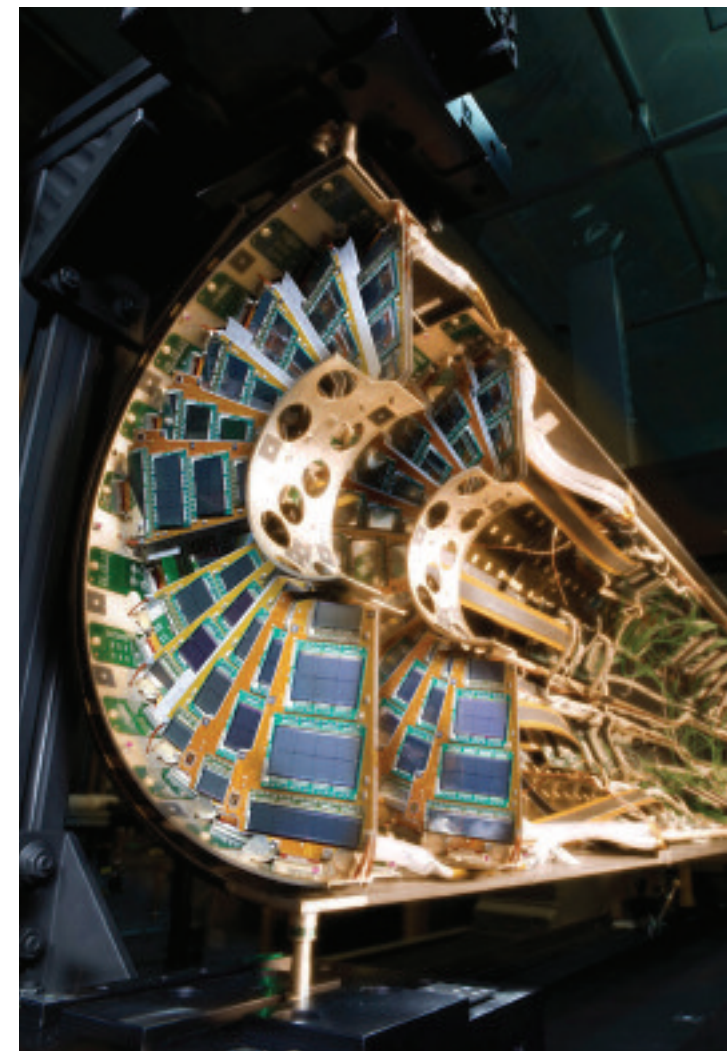
Designing and assembling such a precise instrument required the combined expertise of thousands of researchers. Purdue researchers collaborated with scientists at dozens of other institutions in the United States and around the world. Undergraduates in West Lafayette worked alongside them.

"The Purdue students are extremely good. They are the equal of government technical staff at national laboratories," Shipsey says. In exchange for a stipend, undergraduates received valuable hands-on experience.

"It was really exciting to see something go into action that I contributed to. Not many people my age can say that," says Alan Lichti, a senior mechanical engineering technology major who helped design the mechanical fixers with which the team assembled the chips in the particle detector.

Bridging together time zones and cultures was not simple, but a unifying goal made it possible. "The objective that drives our collaboration is the desire to open and study a new physics frontier," says Bortoletto. "We are learning how to collaborate on a global scale because there is only one LHC. We collaborate with the common goal of advancing science."

Adds Shipsey, "The image of a scientist working alone coming up with a great idea or a great measurement is not something that applies to this type of work. Instead, you're part of a big team. This is a wonderful example of international collaboration and a good model for the whole world to follow." Ultimately, that model might lead scientists to discover the answer to some of life's biggest questions. □



CMS Forward Pixel Detector (FPix)

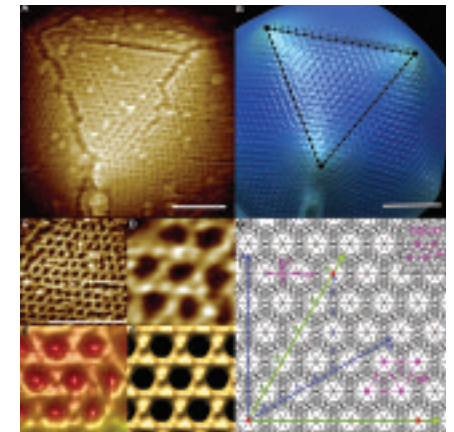
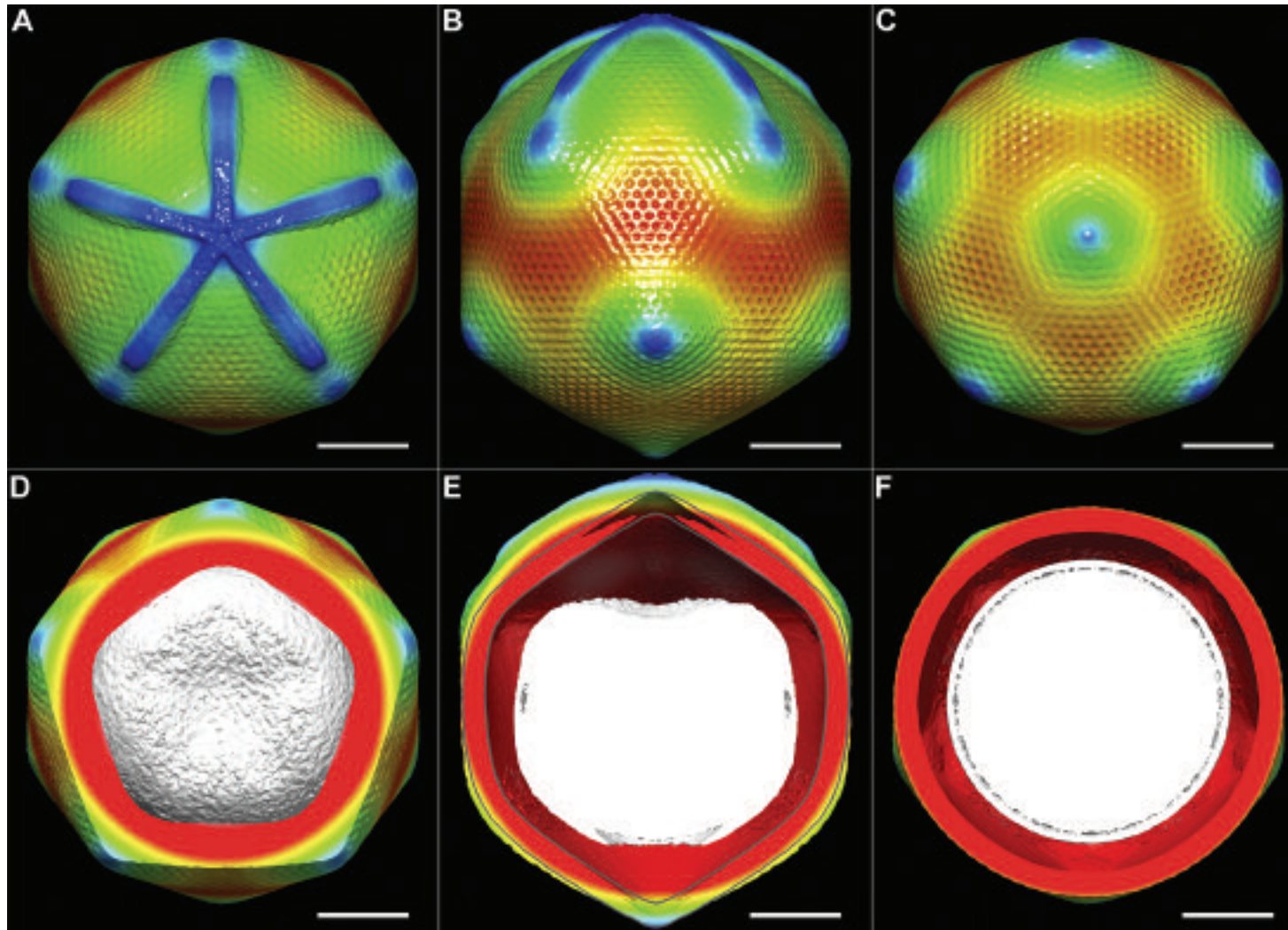
Studying the Mimivirus

Like a mountain climber interested in what can be seen from the next peak, Michael Rossmann's scientific interests continually draw him to explore.

"I'm curious," the Hanley Distinguished Professor of Biological Sciences at Purdue University says of his studies of *Acanthamoeba polyphaga mimivirus*. "Scientific investigation is determined by human curiosity. This virus is larger than any

we've ever known, and many of its properties are non-virus-like, which tickles our curiosity. It's like seeing a big mountain—you want to go and climb it."

More than 1,000 times the size of the virus that causes the common cold, Mimivirus behaves in a parasitic fashion like other viruses, but it also bears many bacterial properties, Rossmann says.



(left) Renderings reconstructed from cryo-electron microscopy images, the Mimivirus bears a starfish-shaped structure that covers an opening in the virus coat through which DNA might be expelled when infecting a host. The DNA is enveloped in a membrane, seen in gray in these (D, E, F). This membrane is concave beneath the starfish-covered opening.

(top) Atomic force microscopy reveals cracks outlining one triangular face on a mimivirus coat sheared of its surface fibers (left). The cracks aren't consistent from face to face, suggesting some instability in the coat. The rendering (right) shows unusual surface depressions that, upon closer inspection, are actually holes.

“A virus is considered to be dead because it can’t live without a host,” he says. “But bacteria can reproduce, so they’re considered to be alive.” Mimivirus blurs the lines between these two definitions.

The virus was first isolated in 1992 from water towers in Bradford, England, where outbreaks similar to Legionnaire’s Disease had been occurring. While the amoeba was never implicated in the illness, study of it led to new information. Its complete genome sequence was later determined by Didier Raoult, professor at Marseille School of Medicine and president of Universitede de la Mediterranee in Marseille, France.

“When I first read about the virus in the journal, *Science*, I wrote to Didier, and since then we have been working together on it,” Rossmann says. A former graduate student of Rossmann’s, Alexander McPherson, now at the University of California at Irvine, has since joined the two professors in their Mimivirus studies.

Starfish-shaped vertex

Rossmann’s laboratory is researching the virus using cryo-electron microscopy, taking thousands of images and averaging them together to reveal intricate details. Along with examining its structure and components, they’re also looking at the virus’s maturation and life cycle.

“Every virus has a life cycle. It infects a host, replicates,

assembles, leaves the host, and moves on,” Rossmann says. “We are determining the life cycle for Mimivirus, primarily in a structural sense. We want to understand how the virus enters the cell, and what happens after that.”

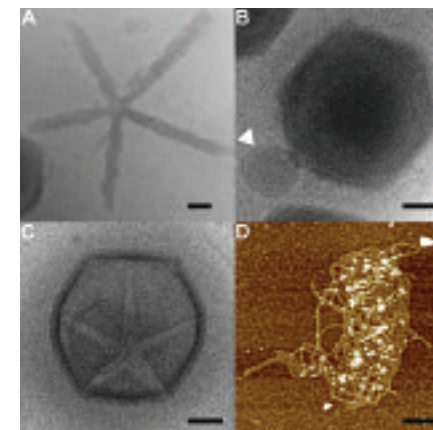
Already, the collaborative efforts at the three universities have yielded information on the basic design of the virus’s outer shell, or capsid. Researchers have also confirmed that the virus has a distinctive vertex, an opening at one end of the capsid. Shaped like a starfish, the vertex appears to open up like a blooming flower, enabling the virus to release DNA for insertion into the host.

These findings help confirm that the Mimivirus is a mixture of genes, viruses, part bacteria, and eukaryotes.

On the fringes

While it’s not known whether or not the virus is a human pathogen, the researchers are taking Level II biosafety precautions anyway. “The majority of people carry antibodies to Mimivirus; many may have been exposed to the virus but have no visible sign of disease,” Rossmann says. “Still, we are careful how we work with it.”

Beyond that metaphorical curiosity to climb the next mountain, the real interest to Rossmann is the fact that the Mimivirus exists on the fringes between life and death—and its implications. □



Michael Rossmann

BRIEF | Thinking solar

Imagine for a minute that the world has just run out of fossil fuels. How would you fly 747s, operate iMacs, process soybeans, and heat and cool your home?

“If that were to happen,” says Rakesh Agrawal, the Winthrop E. Stone Distinguished Professor of Chemical Engineering, “solar power could sustain us not only with the current rate but also with the expected increased future rates of energy consumption.” But harnessing the sun economically would require a tremendous supply of brain power, something that

Agrawal, Hugh Hillhouse, and their colleagues are trying to cultivate through a new certificate program.

Funded in part by the National Science Foundation, SEIGERT (Solar Economy Integrated Graduate Education Resource and Training) will help engineers, scientists, and economists discover breakthrough technical solutions. The interdisciplinary program is designed to prepare graduates for work within existing companies, startups, and academia.

(continued next page)

Enterprising technology

Vladimir Shalaev is boldly going where no researcher has gone before. Last spring, he and his colleagues announced the development of a new, simpler cloaking device that works for all colors of the visible spectrum.



Vladimir Shalaev

Using a specially tapered waveguide crafted from glass and gold, the researchers shielded an area about 50 microns in diameter. While that was roughly the width of a human hair, it was 100 times larger than previously possible. The waveguide also was relatively inexpensive to create.

"All previous attempts at optical cloaking have involved very complicated nanofabrication of metamaterials containing many elements, which makes it very difficult to cloak large objects," says Shalaev, the Robert and Anne Burnett Professor of Electrical and Computer Engineering. "Here, we showed that

if a waveguide is tapered properly, it acts like a sophisticated nanostructured material."

The novel cloaking technology—akin to the Romulans' cloaking device in the fictional *Star Trek* television series—is part of the new frontier of transformation optics. Potentially, advances in the field could lead to not only large cloaking machines but also advanced sensors, computers that use light instead of electronic signals to process information, and hyperlenses 10 times more powerful than those used in microscopes today.

"Transformation optics...represents a new paradigm for the science of light," says Shalaev, who received the 2009 Herbert Newby McCoy Award in part for helping to pioneer this field. "Whereas relativity demonstrates the curved nature of space and time, we are able to curve space for light, and we can design and engineer tiny devices to do this." □

"The transition away from fossil fuels to a new solar economy necessitates major changes to the U.S. infrastructure and redefines the skill set required by our workforce," says Hugh Hillhouse, associate professor of chemical engineering. Through guest lectures, classes, research, and simulations, students can envision an economy fueled entirely by the sun.

"The first course covers the whole landscape of energy—coal, natural gas, nuclear, and solar," Agrawal says. "This will give

them perspective on what our needs are and how they are being met today." After that, students will take a series of required and elective courses in engineering, earth and atmospheric sciences, economics, and leadership and entrepreneurship, honing their technical as well as managerial skills. The coursework reflects the diverse disciplines of the investigators working collaboratively on this grant—Agrawal and Hillhouse are both chemical engineering professors; Wally Tyner is the James and Lois

Ackerman Professor of Agricultural Economics; and Brenda Capabianco is an associate professor of science education. □

Solar Energy Research Group members (left to right) Bryce Walker, Jim Moore, Hye Yeon Park, Mahaprasad Kar, David Yang, Grayson Ford, Hugh Hillhouse, and Rakesh Agrawal.

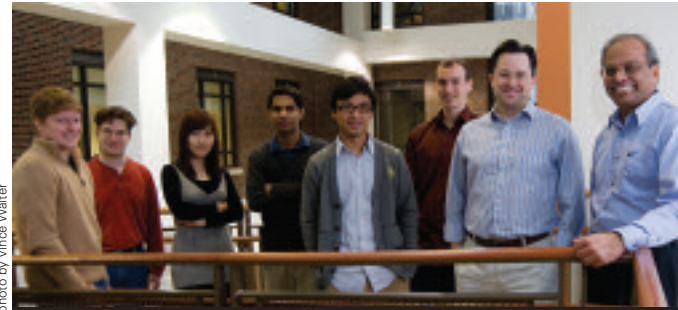


photo by Vince Walter

BRIEF || Tiny technology, big payoff

From two-pound netbooks to 52-inch flat-screen televisions, digital electronics are becoming increasingly more powerful and streamlined. Now, a discovery by Purdue University and IBM may allow engineers to continue improving technology at its current exponential rate.

The researchers have discovered that tiny structures known as silicon nanowires form very reproducibly, potentially making them ideal for future computers and other electronic devices.

Employing a transmission electron microscope, they observed how these sili-

con nanowires solidify, in the same way that pools of water turn to ice.

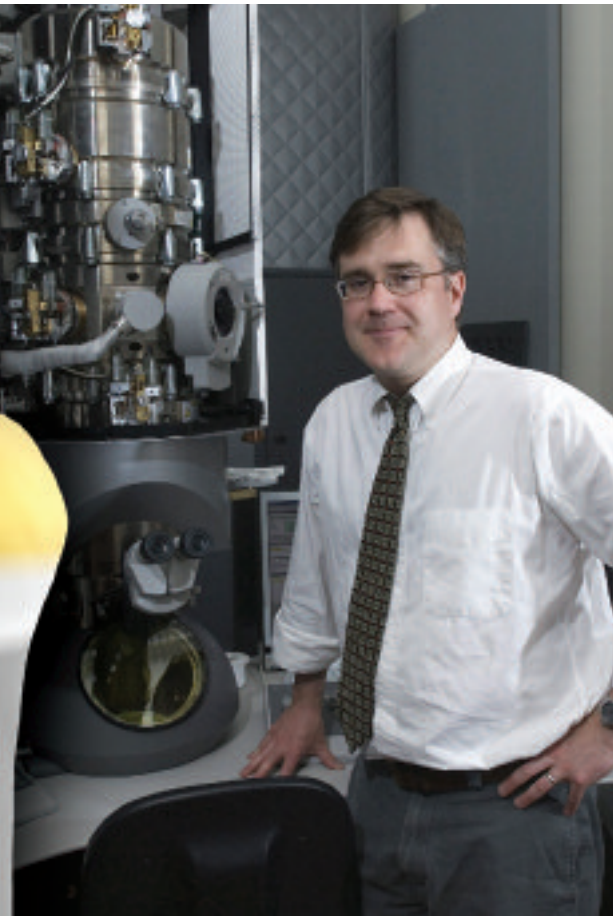
What they found, says Eric Stach, associate professor of materials engineering, is that "the nucleation process on this small scale is highly repeatable, that you can measure and predict when it's going to occur, and that those two facts together give you a sense that you



could confidently design systems to manufacture these nanowires for electronics.”

The breakthrough could help engineers solve a problem that threatens the future of the electronics industry. Moore’s law observes that the number of transistors on a computer chip doubles about every 18 months. While the phenomenon explains why digital products have progressed so rapidly, transistors have become so small now that eventually they will be impossible to shrink anymore.

“In something like five to, at most, ten years, silicon transistor dimensions will have been scaled to their limit,” Stach says. Manufacturers will need new materials to work with, and silicon nanowires might provide the big payoff they’ve been waiting for. □



Purdue News Service photo/David Umberger

Eric Stach, associate professor of materials engineering at Purdue University, stands beside the new FEI Titan electron-microscope at the Birck Nanotechnology Center. The \$4 million instrument, located in a lab at Discovery Park, will allow researchers to take images of the internal structure of nanomaterials, capturing dynamic images of atomic motion during materials processing.

BRIEF | Creating safer spacecraft

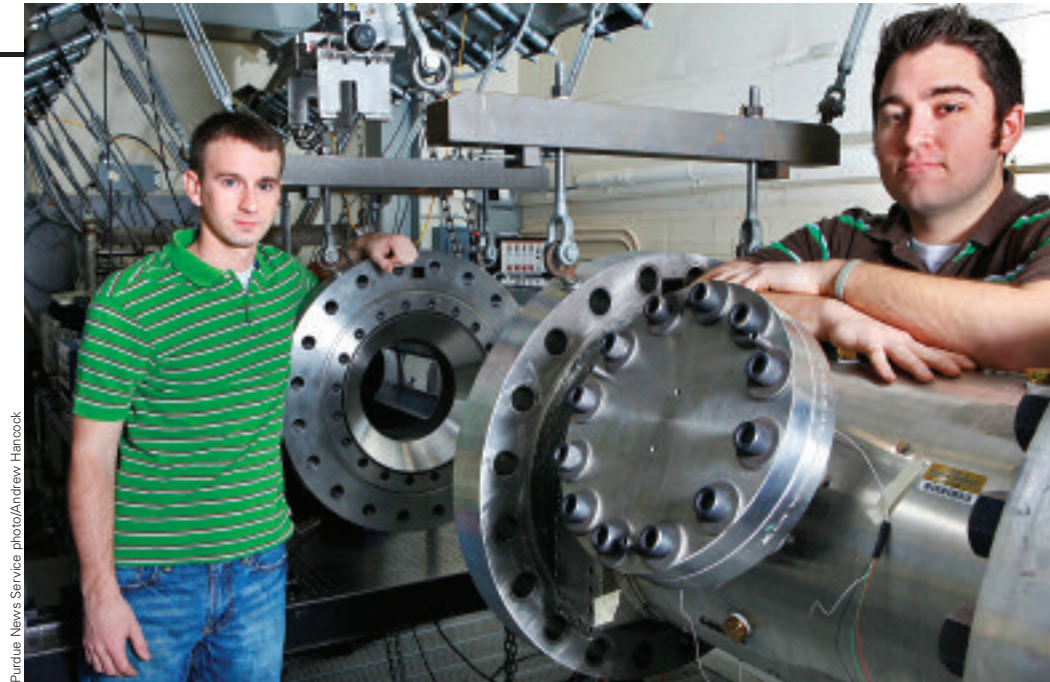
Last year, when Discovery astronauts zoomed back toward planet Earth, NASA scientists breathed a collective sigh of relief as properly functioning heat shields helped prevent the space shuttle from disintegrating upon reentry. But once the shuttle touched down safely at Cape Kennedy in Florida, they began gathering data that could help prevent future deadly thermal protection system failures like Columbia’s in 2003.

Steven Schneider, a professor in Purdue’s School of Aeronautics and Astronautics, helped plan an experiment involving a roughness element installed on the shuttle’s heat-shielding panels. Raised about a quarter of an inch above the panels, the element will help explain how air turns from smooth to turbulent, allowing engineers to design a safer shield for NASA’s planned Orion crew exploration vehicle.

Friction and heating increase along with aircraft speed, eventually damaging heat-shielding systems. In order to protect space vehicles and also hypersonic aircraft—vehicles that travel nearly 4,000 miles per hour—scientists need a better understanding of turbulence.

“We have been arguing in favor of doing some sort of space shuttle flight experiment, and after the Columbia accident there was a lot more attention paid to aero heating,” says Schneider.

(continued next page)



Purdue News Service photo/Andrew Hancock

Brad Wheaton (left), and Peter Gilbert, graduate students in aeronautics and astronautics at Purdue, stand near a segment of a special type of wind tunnel capable of running quietly at hypersonic speeds. Experiments using the wind tunnel are enabling engineers to study how air turns from “laminar,” or smooth, to turbulent, and findings will help researchers determine how to control deadly friction and heating in the design of future spacecraft, advanced missiles, and “hypersonic” aircraft powered by engines called scramjets.

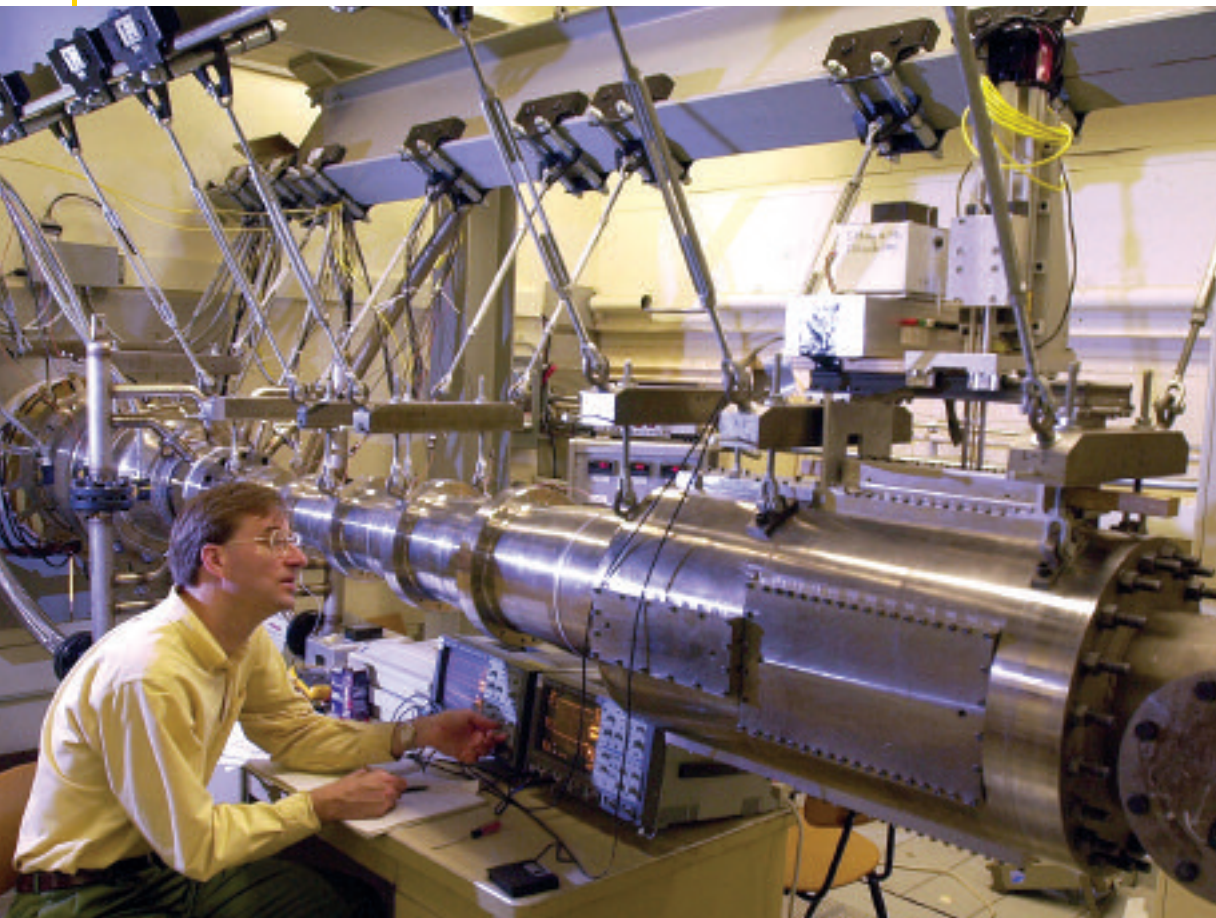
“...no single experiment, whether on the ground or in flight, can give you everything you want.”

—Purdue Professor of Aeronautics and Astronautics Steven Schneider

Steven Schneider, an aerospace engineer and professor in Purdue's School of Aeronautics and Astronautics, operates the University's one-of-a-kind wind tunnel, which runs quietly at Mach 6, or six times the speed of sound. Researchers will use the \$1 million wind tunnel to help design advanced aircraft that travel at hypersonic speeds, or faster than Mach 5, which is about 4,000 miles per hour at sea level.

The research, which is also planned for two more shuttle missions, will complement experiments being conducted at the Boeing/AFOSR Mach 6 Quiet Tunnel at Purdue.

“It is very desirable to conduct an experiment like this under real flight conditions on a real shuttle instead of a model,” Schneider says. “But no single experiment, whether on the ground or in flight, can give you everything you want.” □



Purdue News Service photo/David Umberger

Mark Lundstrom



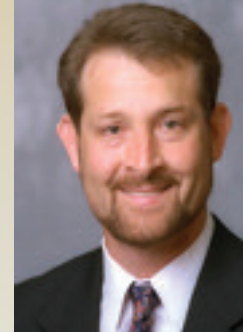
Doraiswami Ramkrishna



Kumares Sinha



Andrew Weiner



National Academy of Engineering inducts four from Purdue

Four Purdue University faculty members who have helped to advance their fields have been inducted into the National Academy of Engineering (NAE).

In 2009, the NAE elected **Mark Lundstrom**, the Don and Carol Scifres Distinguished Professor of Electrical and Computer Engineering, and **Doraiswami Ramkrishna**, the Harry Creighton Peffer Distinguished Professor of Chemical Engineering. In 2008, NAE inducted **Kumares Sinha**, the Edgar B. and Hedwig M. Olson Distinguished Professor of Civil Engineering, and **Andrew Weiner**, the Scifres Distinguished Professor of Electrical and Computer Engineering.

“Election to membership in the National Academy of Engineering is one of the highest distinctions that can be bestowed on an engineer,” says Leah Jamieson, Purdue's John A. Edwardson Dean of Engineering and a 2005 academy inductee. Purdue now has 21 current and retired faculty members in the academy. □

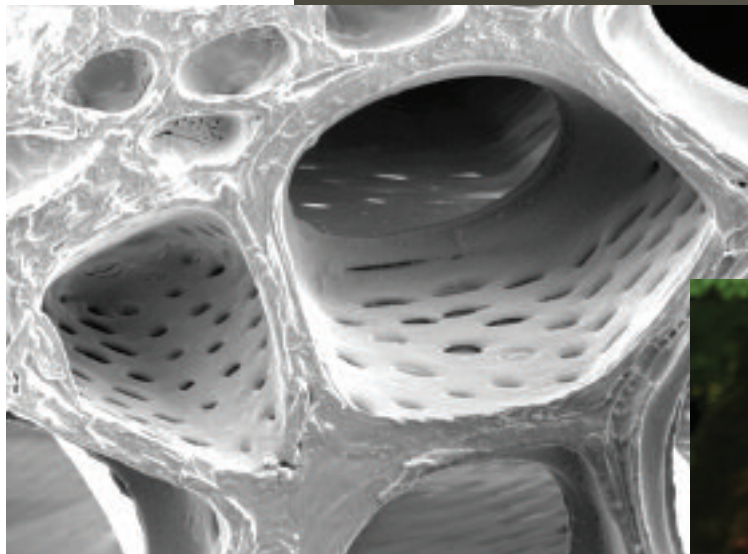
FOCUSING ON PLANET EARTH AND ITS PEOPLE While many eye the universe, research about our own planet and those who populate it also bears rich fruits of understanding and advancement. The more we know about Earth and humans, flora and fauna, the better we are able to sustain the planet and each other.

This takes many forms at Purdue University, from the study of the earth itself to creating renewable resources, advancing our health, feeding our people safely, and expanding our ability to learn and relate.

While we reach for the stars, we appreciate, too, that we have much to learn here, and many Purdue research projects and programs are dedicated to advancing knowledge of our home and our people.

PLANET EARTH

Researchers land funding in biofuels, earthquake, homeland security centers



(left) Structure of a plant cell wall.
(below) Associate Professor of Biological Sciences Maureen McCann is the principal investigator on the C3Bio grant from the Department of Energy.



Maureen McCann

Three of today's major global interests are about to be advanced, thanks to Purdue researchers and some \$135 million in funding. The areas: biofuel development, earthquakes, and homeland security.

C3Bio Center

A Purdue University project to investigate methods to use chemical catalysts and nanotechnology to directly convert plant biomass to transportation fuels and other value-added, bio-based products received a \$15 million, five-year grant from the U.S. Department of Energy.

The approach is a first, and it bypasses the current process that involves biological fermentation, says Maureen McCann, associate professor of biological sciences and project leader. Bypassing the fermentation process could help scale down biorefinery size and expense.

(continued on next page)

“It may even make mobile hydrocarbon refineries possible, where you could take the refinery to the field instead of having to transport heavy biomass to another location,” she suggests.

The money funds establishment of the Center for Direct Catalytic Conversion of Biomass to Biofuels, dubbed C3Bio,

which is headquartered in the Bindley Bioscience Center at Purdue.

An interdisciplinary research team, with experts from biology, chemistry, and chemical engineering, hopes to produce fuels resembling gasoline in terms of molecular composition and energy density.

“The science of chemical catalysis hasn’t been applied much to turning biomass into biofuels,” McCann says. “We think there is a real gap in applying a science that is the foundation of the petrochemical industry, but for which very little research exists on living plants.”

Purdue is partnering with the University of Tennessee, the National Renewable Energy Laboratory, and Argonne National Laboratory in the work.

“The center will bring together a massive amount of talented work and apply it to the next step in achieving a viable alternative energy source to finite and foreign oil,” McCann says.

Reducing earthquake, tsunami devastation, loss

A \$105 million, five-year National Science Foundation award funded the launch of the Network for



photo by Vince Walter

NEES team members

(front row left to right) Dawn Weisman, Barb Fossum, Julio Ramirez, Debra Nahlik, Melanie Lindsay, Rudolf Eigenmann, Sean Brophy, (back row left to right) Ayhan Irfanoglu, Meagan Kramer, Thomas Hacker, Dave Kotterman, Saurabh Bagchi, and Brian Rohler.



Julio Ramirez

Earthquake Engineering Simulation Community and Communications (NEEScom) Center in the the Hall for Discovery and Learning Research.

It serves as headquarters for 14 earthquake engineering and tsunami experimental facilities at universities across the nation.

Through research, cyberinfrastructure, education, outreach, and management of these extended sites, the center is focusing on reducing devastation and loss of human life caused by earthquakes and tsunamis worldwide. Center activities include infrastructure simulations and the NEES Academy for virtual, cyber-enabled learning. The center will help researchers share information and equipment and educate workers in hazard mitigation.

“Recent events have highlighted the importance of earthquake engineering,” says Julio Ramirez, Purdue civil engineering professor and center director. In the last decade,

124 major earthquakes occurred in the world, taking the lives of more than 460,000 people, according to the U.S. Geological Survey.

Managing homeland security data

Data, data everywhere. Making good use of it, especially when it concerns homeland security, is a task Purdue University is co-leading with Rutgers University under the Center of Excellence in Command, Control, and Interoperability, a Homeland Security international research and education group.

The group will receive \$30 million to master data analysis and management, with the focus on preparing for, detecting, preventing, responding to, and recovering from terrorist attacks and disasters.

Purdue is overseeing the Visualization and Analytics for Command, Control, and Interoperability Environments, an 18-university team with a \$15 million budget for the six-year project.

“We are developing ways to analyze, manage, synthesize, and visualize huge collections of data that come from a multitude of sources—camera images, sensors, simulations, and police and healthcare reports,” says David Ebert, team director, and Silicon Valley Professor of Electrical and Computer

Engineering

“This will help everyone from first-responders on up perform their jobs more effectively should catastrophe strike, whether it’s a chemical spill, natural disaster, disease outbreak, or terrorist attack.” □



David Ebert



Purdue University photo/Andrew Hancock



(top) Purdue doctoral student Ross Maciejewski uses a type of visualization related to work being led by the University in a new center called Visual Analytics for Command, Control, and Interoperability Environments, or VACCINE, funded by the U.S. Department of Homeland Security.

(left) Purdue officials unveiled a national center to help homeland security and emergency personnel respond to and manage a variety of calamities, from disease outbreaks to economic crises.



Purdue University photo/Andrew Hancock

Casting new light on cancer treatment

Twinkling like stars against the night sky, gold nanoparticles produce distinctive pulses of light while gyrating in sync with a rotating magnetic field. Measuring about 100 nanometers from tip to tip, the nanostars may hold the promise for early cancer diagnosis.

The near-infrared pulses from the nanostars can pass through biological tissue more easily than visible light, and may someday allow pathologists to detect tumors at an earlier stage of development.

“This is a very different approach to enhancing contrast in optical imaging,” says Alexander Wei, a professor of chemistry and member of the Purdue University Center for Cancer Research. “We don’t want to oversell this new technology, but we hope it will prove useful in developing methods for early detection.

“Brighter isn’t necessarily better for imaging; the real issue is background noise, and you can’t always overcome this simply by creating brighter particles. With gyromagnetic imaging, we can zero in on the nanostars by increasing signal strength while cutting down on background noise.”

Targeting treatment

Nanomedicine also is casting a new light of sorts on the search for more effective cancer treatments. Dr. Debbie Knapp and Professor Jim Leary are investigating how antibody-targeted nanoparticles can treat urinary bladder and other cancers. They’re starting with the treatment of mice, then will follow with dogs and ultimately humans.

Nanotechnology has the potential to address the collateral damage that often accompanies traditional chemotherapy. Many cytotoxic drugs don’t differentiate between normal and cancerous cells and end up wiping out both, causing not only short-term side effects like hair loss and nausea,

but also long-term, devastating ones, like damage to nerves and organs.

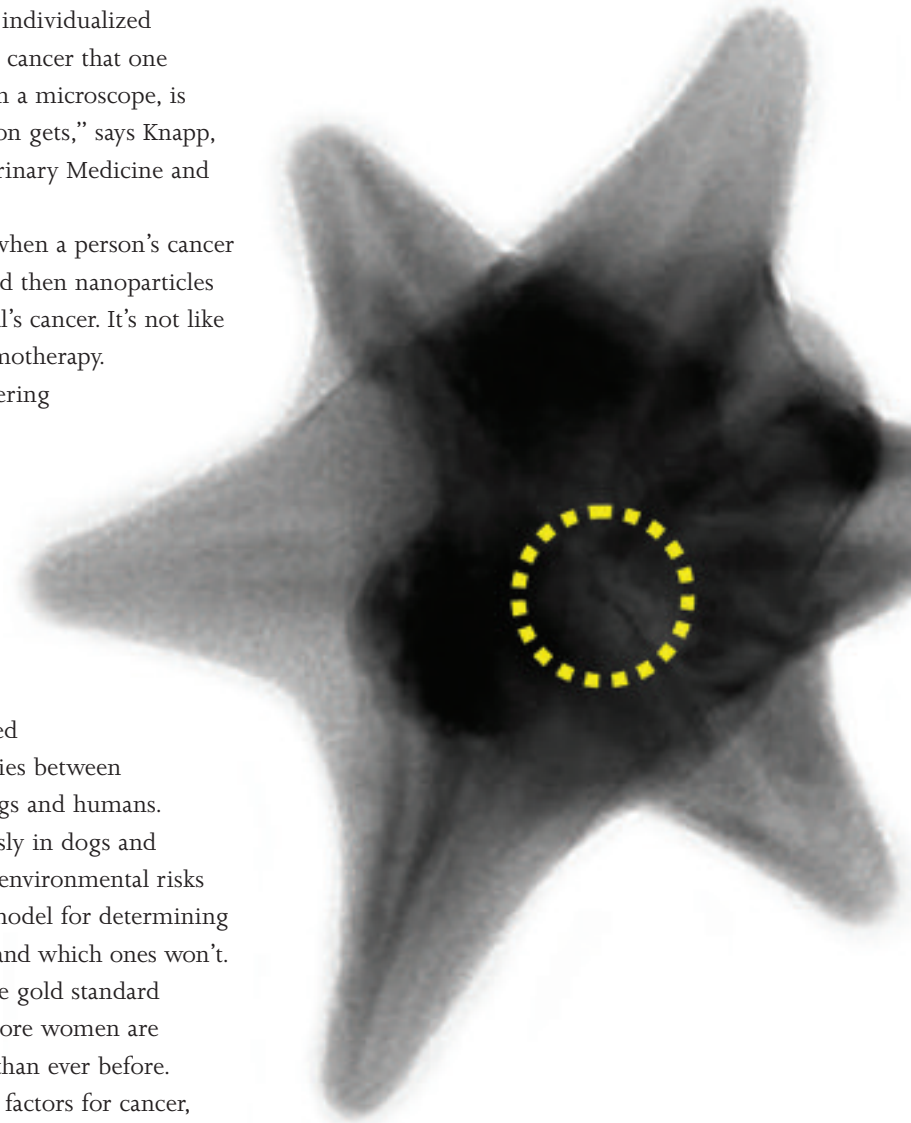
Targeting also could provide a more individualized approach to cancer care someday. “The cancer that one person gets, even if it looks the same in a microscope, is different from the cancer another person gets,” says Knapp, the Dolores L. McCall Professor of Veterinary Medicine and a specialist in canine cancer care.

“There will be a time in the future when a person’s cancer can be analyzed at a molecular level and then nanoparticles will be designed to treat that individual’s cancer. It’s not like the shotgun approach of standard chemotherapy. It’s more of an individual way of delivering cancer drugs. And this should be a much more successful approach.”

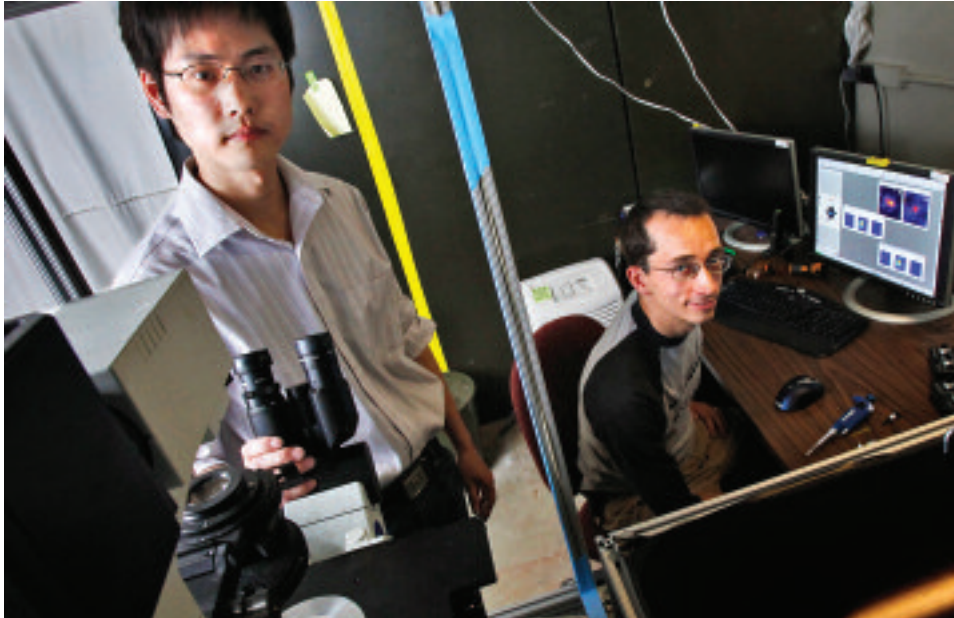
Striving for a new standard

Knapp’s work with canines complements that of her colleague, Professor Sulma Mohammed. Two years ago, Mohammed and her colleagues discovered similarities between pre-malignant mammary lesions in dogs and humans. Because the lesions appear spontaneously in dogs and because dogs are exposed to the same environmental risks as humans, that makes them an ideal model for determining which lesions will develop into cancer and which ones won’t.

Since mammography has become the gold standard in screening for breast cancer, many more women are diagnosed with abnormal cell growth than ever before. Because the lesions are considered risk factors for cancer, their discovery drives preventive care.



Gold nanostar with a magnetic core.



Purdue University photo/Andrew Hancock

Graduate students and research team members Qingshan Wei and Jacob Hale work with equipment used for gyromagnetic imaging of gold nanostars.

Hormonal therapy is usually prescribed if the lesions are estrogen-receptor (ER) positive. No treatments are available, however, when women have high-risk or ER-negative lesions. By studying tissue samples of dogs, Mohammed can see if malignancies develop and also determine which medical interventions are most likely to prevent their occurrence.

“To stop any disease, you need to develop a model of intervention,” says Mohammed, an associate professor of cancer biology. “Dogs provide an animal model for preclinical work, essentially biological studies so that we can understand the disease better before we try treatments on humans.” □

Easing hunger in Africa

Clusters of sorghum crops wave gently in an arid breeze just west of the White Nile River in Sudan, their patchworks of gold and green painting an image of agricultural prosperity. Two decades ago, poor yields threatened livelihoods and lives there.

Ejeta, who grew up in a one-room hut in Ethiopia, saw firsthand the devastation wrought on sorghum crops. After years of research, he bred sorghum varieties resistant to Striga, commonly called witch weed.

In 1994, Ejeta shipped eight tons of his drought-tolerant and Striga-resistant sorghum seeds to Eritrea, Ethiopia, Kenya, Mali, Mozambique, Niger, Rwanda, Senegal, Somalia, Sudan, Tanzania, and Zimbabwe.

In contrast to traditional sorghum crops, farmers saw yields up to four times larger.



Now, thanks in large part to **Gebisa Ejeta**, sorghum is thriving on the African continent, and a commercial sorghum seed industry has sprouted in Sudan, creating another revenue stream for farmers along the Nile.

Sorghum is a major cereal crop for more than 500 million people in Africa, contributing to such staples as breads, porridges, and beverages. But drought and parasitic weeds such as Striga threaten the agricultural resource, contributing to the hunger crises that have eclipsed much of Africa’s history over the last few decades.

Now, Ejeta has been recognized for his accomplishments with the 2009 World Food Prize. But the Distinguished Professor of Agronomy says he has work left to do. “We need to build stronger human and institutional capacity in African nations to help people feed themselves,” he says. “And we need to encourage the development of similar advances in maize, millets, and other crops of Africa.” □

BRIEF || **Elmo helps kids of deployed parents**

When Mom or Dad is deployed a second or even a third time, youngsters are getting help understanding what's going on from popular Muppet character Elmo. That's the finding in a study by Purdue's Military Family Research Institute, which interviewed families on the effectiveness of specially

developed materials from the nonprofit educational organization, Sesame Workshop.

Participating families received a multimedia test kit titled "Talk, Listen, Connect: Deployments, Homecomings, Changes," which included DVD episodes appropriate for

Sesame Street's Elmo and his dad tape a segment for "Talk, Listen, Connect."



photo by Richard Termine for Sesame Workshop

Breaking new ground

More than 50 years ago, Professor Emeritus **Albert Overhauser** delivered a groundbreaking speech that helped shaped the development of nuclear magnetic resonance technology. Now, the Stuart Distinguished Professor of Physics has been honored for his work with the 2009 Russell Varian Prize.

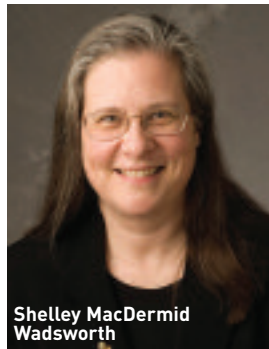
Overhauser was recognized in a July ceremony in Göteborg, Sweden. He previously received the National Medal of Science for his fundamental contributions to physics.

Overhauser was the first to demonstrate that scientists could polarize nuclear spins by a factor 1,000 or so larger than what they previously thought possible. While his ideas originally were met with skepticism in the physics community, his critics came around eventually, and he presented his concept to the American Physical Society on Polarization of Nuclei in Metals.

His findings were subsequently published in *Physical Review* and cited more than 500 times. Since then, the Overhauser Effect has played a key role in liquid state NMR, particularly in establishing structures of biological acromolecules in solution. □

children ages two to five, a parent magazine, and a poster. A control group received similar materials in a package featuring other Muppet characters titled, "Sesame Street Healthy Habits for Life Kit," focusing on nutrition and exercise.

"Caregivers reported they were more likely to use the information in the Elmo test kit and that it significantly changed the way they helped their children cope with deployment," says Shelley MacDermid Wadsworth, professor of child development and family studies and director of the Military Family Research Institute.



"A large majority gave the test kit high overall evaluations."

Founded in 2000 and supported by Lilly Endowment, the Department of Defense and others, the institute is also using \$8.9 million in Lilly funding for a three-year effort to improve the quality of life of military families. It includes researching needs and challenges of families, especially after deployment; providing assistance for military family support workers; and reaching out to professionals serving military families.

The Purdue Institute is the only university-based institute of its kind in the country. □

Purdue's Military Family Research Institute is the only university-based institute of its kind in the country.

BRIEF | Watching the brain work

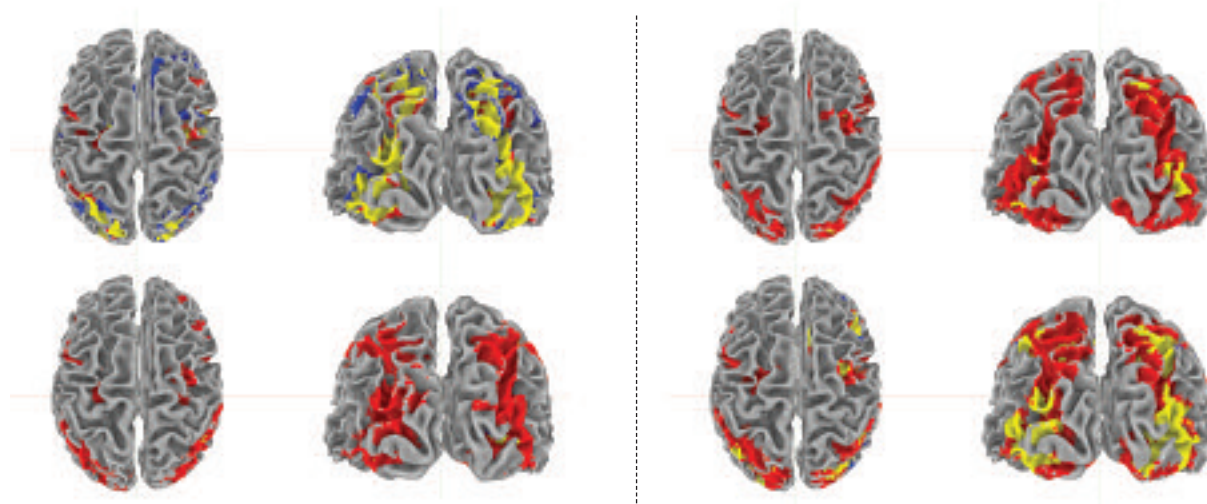
How the brain is engaged during different tasks may depend on a person's specific learning abilities or gifts. That's what Jeff Gilger, former College of Education associate dean for discovery and faculty development and professor of special education, and his team set out to learn in work funded by an Esther Katz Rosen grant from the American Psychological Association.

They hope to identify neurologic and genetic links to giftedness and twice exceptionality, in which a person has both giftedness and a learning disability. To watch brain activity, researchers had subjects perform word and spatial manipulation tasks during magnetic resonance brain imaging.

Early findings are providing interesting scientific data, Gilger reports. When people with dyslexia read, three parts of the left hemisphere are under-engaged compared to controls; and when performing spatial tasks, the whole brain is used whether the person is dyslexic and/or gifted. In fact, brains of the gifted and twice exceptional subjects were highly activated, especially for the more complex spatial problems. These and other findings may provide a better understanding of how gifts and learning disabilities affect

brain function and later help educators develop and apply appropriate teaching methods.

The team includes George Hynd, College of Charleston; and Tom Talavage and Olumide Olulade, Purdue School of Electrical and Computer Engineering. □



These are axial (right) and posterior (left) views of subjects' brains during spatial tasks. Red areas are active during spatial stimuli requiring rotation. Blue areas are active during spatial stimuli not needing rotation. Yellow areas are active during both types of spatial stimuli.

BRIEF || **Got milk without melamine?**

What began as a training exercise in a Purdue University food science lab quickly produced lifesaving results, garnered *New York Times* coverage, and drew international interest.

The news-making research result: use of infrared spectroscopy methods to easily and inexpensively test for the presence of melamine, a white crystalline chemical compound used in plastics that has been found in imported baby formula. It's especially dangerous for infant consumption, according to the Centers for Disease Control and Prevention.

“Because the structures of melamine and most food ingredients are different, we thought we would pursue the exercise of differentiating ‘adulterated’ and ‘pure’ infant formula,” says Lisa Mauer, associate professor of food science in the College of Agriculture. “We started using much higher concentrations of melamine in the formula, and when that worked, we used smaller and smaller concentrations, down to one part-per-million.”

Now, Mauer reports, “There are several international groups looking at the technique and testing it in industrial settings.”

It's one of many areas Mauer and her research group are exploring. Others include evaluating the effects of processing and water-solid interactions on food ingredients; developing rapid methods to detect microorganisms in foods; and optimizing space food quality for extended missions. □



Lisa Mauer

Lisa Mauer's research lab at Purdue University has tested a variety of oils for purity—from cod liver to vegetable and every imaginable oil in between. Mauer and her research team used infrared spectroscopy and statistical analysis to classify samples of dietary supplement oils, as well as common food oils.

Just as Charles Darwin, Georges Lemaître, and Neil Armstrong model giant strides for today's researchers, so, too, do today's scientists and pioneers of new learning mentor and motivate new scholars. Whose names will represent this decade? The 21st century? What breakthroughs will inspire scholars of the next generation and beyond?

While those chapters remain to be written, many are likely to have ties to Purdue, where an environment of discovery permeates every discipline, where achievements are recognized internationally, and where research opportunities extend even to high school students.

The world—indeed, the universe—awaits these scholars and their contributions.

LAUNCHING NEW SCHOLARS

Increasing women STEM faculty, transforming Purdue



Alice Pawley

Some believe the small percentage of women faculty in science, technology, engineering, and math (STEM), which at Purdue also includes agriculture and veterinary medicine, is due to the narrow pipeline—not enough women choose those fields for there to be many women faculty. Others believe it's “the cold environment universities present to women faculty,” says Alice Pawley, Purdue assistant professor of engineering education.

She's one of a team of researchers across campus led by France Córdova, Purdue president and principal investigator, testing those beliefs, uncovering others and transforming Purdue to be an institution where women STEM faculty succeed.

With nearly \$4 million in a five-year grant from the National Science Foundation's ADVANCE program, whose goal is to increase the number and advancement of women in academic science and engineering careers, this team has established the Purdue Center for Faculty Success.

It's tackling two areas of research—one on University policy; the other on faculty experiences—and offering programs dedicated to the ADVANCE goal.

“We offer networking opportunities across campus to help interdisciplinary collaboration, and we provide programs for mentoring, leadership development, hiring, and work/life balance,” says Deputy Director Suzanne Zurn-Birkhimer.

Its focus areas are recruiting underrepresented women to STEM faculty positions (currently 1 percent at Purdue, with women of all ethnicities holding 15 percent of those posts); increasing STEM women faculty's success and retention; and preparing faculty women for department, center, college, and University leadership. Its final charges extend to everyone on campus: educating faculty about bias and diversity issues and engaging all faculty in transforming Purdue.

What the center learns through its integrated research stands to become a model for other institutions, says



ADVANCE post-doctoral research fellows Saranya Srinivasan and Dina Banerjee (left).

Pawley, who shares co-principal investigator status with Valentine Moghadam, professor of sociology and director of women's studies, and Carolyn Johnson, interim vice provost for diversity and inclusion.

Pawley's research protocols have been established and interviews will be conducted during the 2009-10 academic year. "We are working to find a way for women faculty to share their stories in ways that help their careers and not just the researchers'," Pawley says. "We want to find the edges, or limits, of the pipeline and climate metaphors, and perhaps find other metaphors that can be inclusive of more women in how institutions make decisions on faculty work life. It is potentially game-changing."

Moghadam, meanwhile, is leading work-life policy research and events to promote an environment conducive to faculty success, especially for STEM women of color. Research and discussions revolve around family/parental leave, tenure clock extension, and childcare. "Our overarching goal is to enhance and promote an environment conducive to faculty success, especially for minority women in STEM, through family-friendly policies and programs," she says.

The next step, Pawley says, will be to consider how institutions should be redefined. "How do we design the work of STEM faculty and their environments to not exclude people whose career paths may not be traditional or who may not want to solely focus on their jobs? Unless we redesign these jobs, we can't expect women to choose them."

Yet it is vital that women choose them, Córdova says: "It is essential that more of our domestic students prepare for and enter STEM disciplines and agriculture. These fields are key to global competitiveness." □

Student researches graphene, eyes space



photo by John Terhune/Journal & Courier

Yuri Kubo prepares a probe station for an electrical test in his lab inside the Birck Nanotechnology Center on the campus of Purdue University. Kubo, a graduate student in electrical engineering, was presented with a \$10,000 scholarship from the Astronaut Scholarship Foundation by James Lovell, commander of the Apollo 13 space mission.

Electrical engineering graduate student Yuri Kubo has both a grounded focus and a self-described, pie-in-the-sky goal.

With his feet planted in practicality, he's conducting master's research at Purdue University that could lead to graphene—a single layer of graphite—replacing silicon in transistors. At the same time, he's doing everything he can to position himself

to be chosen for NASA's astronaut program. Both his studies and his quest for the space program got a boost in 2009 when he landed a \$10,000 Astronaut Foundation Scholarship.

"My research currently is in characterizing graphene and doing optical measurements on it," says Kubo, a member of the Intel-funded Joerg Appenzeller Lab Group in the Birck Nanotechnology Center at Purdue. "I'm using an atomic force

microscope to determine if it's one, two, or three layers, then electrically exciting the device to see how current responds," he says. "We're trying to scale transistors down, to see what the next big thing in computer chips can be. This has widespread applications for industry."

Hailing from Columbus, Indiana, Kubo figured he would follow in his father's mechanical engineering footsteps until he tackled an electrical engineering alarm and radio kit in middle school. "It really drew me in. I really enjoyed it," he says. And that led to a bachelor's degree with distinction in electrical engineering in 2008.

Becoming an astronaut is his ultimate dream, he says. As a high school junior, he realized that "the idea of getting off the Earth would be very intriguing." Now, he says, "I'm realizing more and more, it can happen. The master's is the next logical step. Then I can apply for the astronaut course." While he realizes he may not make it the first try, he's willing to keep working at it.

Juggling research and study demands is work, he admits. "When I'm up at 4 a.m. working on projects, I ask myself, 'What am I doing?' I did not get the memo that said it would be this hard."



The potential payoff makes it worth it, he believes. “I constantly strive to be better. When I was young, it was to please my parents. Now, my personal goal is to be the best at whatever I can do. It’s all about that final goal. The sacrifices you make now are negligible compared to what you can achieve.”

Kubo has participated in several cooperative work experiences at the Johnson Space Center in Houston—in flight control, as an electrical design engineer, and as a pyrotechnic engineer. “It’s an amazing program, working in industry, learning things you’ll never learn in the classroom,” he says. “You learn how to work with managers, co-workers, and real projects. There are a lot of nuances you won’t learn in a classroom.”

Time in Houston also gave him a unique opportunity—volunteering to help coach the same girls’ soccer team several summers in a row. “The more you’re connected with the community, the better you are as a person,” he believes. Over the years, he has also tutored about a dozen students at Purdue.

Along with his interests in graphene and space, Kubo says he may like to make a mark one day in renewable energy resources, too. And a doctorate could be on the horizon. □

Monica Cox (*center*) talks with graduate students Tenille Medley and Nathan McNeill during a research meeting.



BRIEF | **Black Panthers a template for educational transformation**

Research done at Purdue University with funding from a Bilsland Fellowship led Omari L. Dyson (PhD, education 2008) to keen insights for education enhancements and a top award.

His dissertation, “The Life and Work of the Philadelphia Black Panthers: The Curricular and Pedagogical Implications of Their Social Transformation Efforts,” examined the political organization from 1968 to 1974 and earned him the 2008-09 Outstanding Dissertation Award for Curriculum Studies from the American Education Research Association.

“The Panthers’ efforts supported Abraham Maslow’s Hierarchy of Needs Theory,” says Dyson, now an assistant professor at South Carolina State University. “Why is it that people are not learning? Well, how can they learn if they come to school hungry and have the bare minimum in clothing? This was my revelation: The Panthers met community needs by addressing the basics: feeding kids and transforming the community.”

His Purdue major professor, Erik Malewski, says, “Dyson was brilliant in his capacity to conduct interviews and do archival research so as to grasp the eclectic and varied forms of education that took place. What he found was a wealth of information about the struggle for self-knowledge, cultural understanding, and participatory democracy.” □



Omari L. Dyson receives his doctoral hood during the 2008 graduation exercises.

BRIEF | **Knocking on the gate of success**

“Perseverance is a great element of success,” Henry Wadsworth Longfellow once wrote. “If you only knock long enough and loud enough at the gate, you are sure to wake up somebody.”



Purdue News Service photo

That philosophy is one that Monica Cox holds near to her heart. An assistant professor in the Department of Engineering Education and the director of the Pedagogical Evaluation Laboratory at Purdue, Cox is striving to fill the pathway for graduate-level engineering programs. Her determination has caught the attention of the White House, which honored her with a Presidential Early Career Award for Scientists and Engineers.

Growing up in rural Alabama where advanced placement classes were unheard of, Cox was never exposed to engineering courses until college. As she overcame those hurdles to advance her education, she noticed a dearth of U.S.-born students pursuing advanced degrees in STEM (science, technology, engineering, and mathematics) fields.

Wondering how many other undergraduates may have missed out on some of those critical preparatory classes, Cox decided to focus on how universities could improve their chances for success. Already, her efforts have garnered more than \$2.4 million in federal research grants, including a National Science Foundation CAREER award for research in engineering education.

“I am excited that our nation’s top thinkers recognize the importance of engineering education research, particularly research exploring the diverse experiences of doctoral engineering students,” says Cox. That recognition, of course, is evidence that the gate is starting to open. □

Haghighi recognized for contribution to engineering education

Kamyar Haghighi, head of the School of Engineering Education in Purdue University’s College of Engineering, received the



Kamyar Haghighi

2009 Chester F. Carlson Award from the American Society for Engineering Education for his contribution in the development of engineering education as

an academic discipline and for leading the creation of Purdue’s Department (now School) of Engineering Education, the world’s first such academic department.

The award, sponsored by Xerox Corp., is named for the inventor of the process that

led to the first copier. It is presented annually to an individual who, by motivation and ability to extend beyond the accepted tradition, has made a significant contribution to engineering education. □

Boltasseva earns 2009 Young Researcher Award

Pioneering research earned **Alexandra Boltasseva**, assistant professor of electrical and computer engineering, the 2009 Young Researcher Award in Advanced Optical Technologies from Erlangen Graduate School in Advanced Optical Technologies (SAOT) at the University of Erlangen-Nuremberg, Germany.

Presented annually to an outstanding young scientist in optics and photonics to pursue research in collaboration with SAOT scientists, the award includes funding, which Boltasseva will use to support

a postdoc at Erlangen and purchase research materials and equipment.

Boltasseva’s research focuses on plasmonics and metamaterials—artificially created nanostructured materials with extraordinary electromagnetic properties. □



© Erich Walter

Alexandra Boltasseva

Purdue's committed sponsors share in the vision of advancing the frontiers of knowledge and delivering innovative solutions to the public. Sponsors play an essential role in providing the necessary partnerships and support that enable new trajectories for scholarly activity.

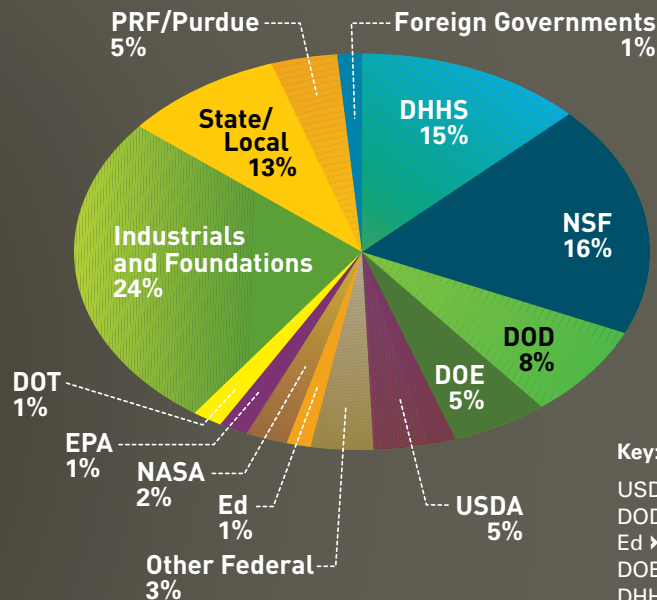
RECORD-BREAKING FUNDING

A record \$342.2 million in sponsored research funding was made payable to Purdue University during the 2008-09 fiscal year, an increase of 2.6 percent from the previous year's \$333.4 million.

Funding sources included private industries, the National Science Foundation, several federal government departments, some state and local grants, and support from foreign governments.

Multiple sources

Supporters of Purdue research activities can be found in industry and government.

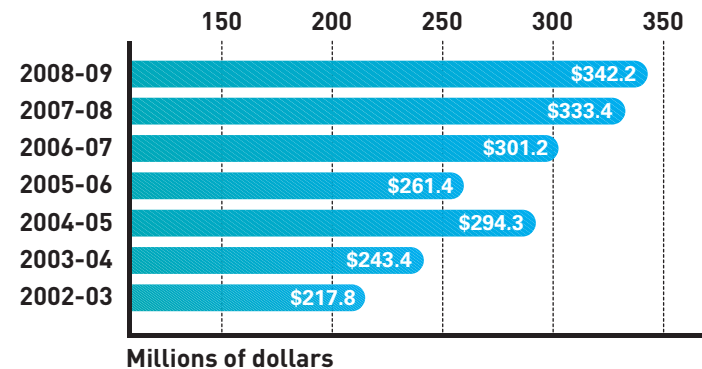


Key:

- USDA » U.S. Department of Agriculture
- DOD » U.S. Department of Defense
- Ed » U.S. Department of Education
- DOE » U.S. Department of Energy
- DHHS » U.S. Department of Health and Human Services
- DOT » U.S. Department of Transportation
- EPA » U.S. Environmental Protection Agency
- NASA » National Aeronautics and Space Administration
- NSF » National Science Foundation

Ever-increasing sponsorship

Purdue University research requests continue to land significant funding.



Showcasing scholarly activities

Purdue faculty and researchers are highly accomplished as they communicate their knowledge and its potential benefits to the world. This collage represents a sampling of recent activities.



G



From the **PRESIDENT** >>

Meeting global challenges

Purdue University's rich history of discovery inspires students and faculty to explore new worlds of possibilities. This report reflects many of those endeavors and outstanding accomplishments. Purdue graduates and scholars have left their mark on the world and in our solar system, from leaving man's first footprint on the Moon to easing hunger in Africa. Intent on advancing the frontiers of knowledge, Purdue investigators are

building the new synergies across disciplines that are essential to addressing areas of critical need.

—France A. Córdoba, *President*



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

Promoting discovery with delivery

Discovery never ends. Purdue investigators made enormous contributions to the field of electronics, now vital to our daily lives. Today, Purdue researchers are making transformational discoveries that may someday use the science of light to replace electronic signals. In the future, new discoveries will lead to innovative materials not yet heard of that could change the way we live, work, and play. Research at Purdue changes lives and impacts

the future. It's an exciting time for discovery at Purdue.

—Richard Buckius, *Vice President for Research*



From the **PROVOST** >>

Launching tomorrow's leaders

Today, a Purdue education offers many opportunities to engage in the discovery process at all levels, and the added value of hands-on research experience is preparing Purdue graduates for the knowledge economy. Faculty members are continuing Purdue's legacy of pushing the boundaries of knowledge and are inspiring a new generation of scholars.

—Randy Woodson, *Provost*

What's discovered today in Purdue University laboratories stands to become tomorrow's commercial successes. Those providing assistance in the move from findings and development to the marketplace include Purdue Research Foundation's Office of Technology Commercialization and the Purdue Research Parks, also operated by Purdue Research Foundation.

DELIVERING INNOVATIVE SOL

Technology commercialization

Housed in the recently completed Herman and Hedly Kurz Purdue Technology Center in the Purdue Research Park of West Lafayette, the Office of Technology Commercialization protects, markets, and licenses Purdue's intellectual property.

More than 250 technologies are available for licensing. Among them are an optical pulse train generator, a flow sensor, a watermark for digital images, and a tire health monitoring system.

"In the last fiscal year we had more than 350 patent applications, licenses, and startup companies based on the discoveries of Purdue researchers, and we have 62 Purdue University faculty members who are directly involved with creating and developing new companies at the Purdue Research Park," reports Joseph Hornett, senior vice president, treasurer, and chief operating officer of Purdue Research Foundation, which oversees the Office of Technology Commercialization.

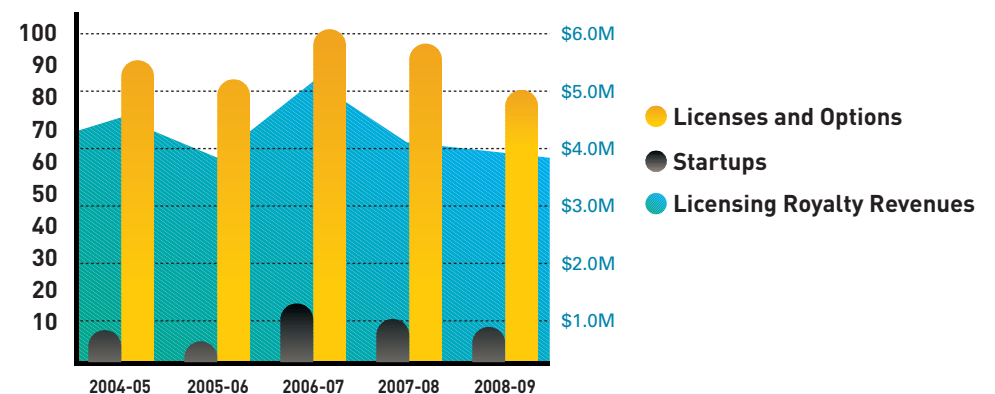
"That number demonstrates well the magnitude of Purdue faculty discoveries and the important role the Office of Technology Commercialization provides to move them to the public," Hornett says.

Purdue research parks

Purdue Research Foundation operates four research parks in Indiana, all with space for high-tech and life-science startups:

- » Indianapolis, with 55,000 square feet of incubator space
- » Merrillville, with 48,000 square feet of incubator space and another 12,000 square feet planned for 2010
- » New Albany, with 18,000 square feet of incubator space
- » West Lafayette, with 364,000 square feet of incubator space □

2008-09 Technology transfers, revenues



UTIONS



More than 200 people gathered for the dedication of the Herman and Heddy Kurz Purdue Technology Center in the Purdue Research Park. The 105,000-square-foot facility will house the Purdue Research Foundation offices, provide space for up to 26 companies, and support up to 275 jobs.

Purdue University photos/Andrew Hancock

2008-09 STARTUP VENTURES

The seven companies that licensed Purdue technologies and were launched during the 2008-2009 year are:

- » *Advanced Bioimaging Systems LLC*
+ **West Lafayette, Ind.** Developing a new platform technology to rapidly and non-invasively detect bacterial colonies using light-scattering patterns; technology will help fight bacterial growth at its origination.
- » *Events 180°*
+ **West Lafayette, Ind.** Develops software for the cellular communications market; provides real-time sports statistics, on-demand instant replays, and venue information at football games.
- » *Fast Forensics*
+ **West Lafayette, Ind.** Licensed apparatus and method for military, federal investigative agents, and state and local law enforcement personnel to acquire, analyze, preserve, and report information from seized or found mobile phones, PDAs, USB thumb drives, and portable media on-scene.
- » *Genomic Guidance LLC*
+ **Crawfordsville, Ind.** Developing DNA screening that can be used at the clinic level to help predict how a person is likely to respond to anticoagulants and other drugs; now in business plan and funding stage.
- » *iCyt Mission Technology Inc.*
+ **Champaign, Ill.** Producing cell sorters and flow cytometers used in the life sciences and healthcare industries; the technology may improve the quality of clinical research and is expected to have a lasting impact on clinical diagnostics and cell-based therapies.
- » *Karyozen LLC*
+ **West Lafayette, Ind.** Developing cell-based biosensors for pathogens and toxins using proprietary technology; company product will help in bio-defense and clinical infectious disease markets.
- » *Pfeiffer Engineering LLC*
+ **Booneville, Mo.** Provides engineering design, visualization, and analysis services, primarily for bio-mechanical and biomedical applications for the biomedical device industry. □

Byrn receives 2008 commercialization award

Stephen Byrn, the Charles B. Jordan Professor of Medicinal Chemistry at Purdue, received Purdue University's 2008 Outstanding Commercialization Award. Byrn is co-founder along with his wife, Sally, of SSCI, an Aptuit Company.



Founded in 1991 to provide professional development short courses and other educational services to the pharmaceutical industry, the company opened an analytical lab in Purdue Research Park in 1993 and began offering contract research.

SSCI was acquired by Aptuit in 2006, and today employs 100 at its West Lafayette, Indiana facility.

Given for the sixth time in 2008, the award is sponsored by the Central Indiana Corporate Partnership. □

Purdue Research Foundation lands awards

Purdue Research Foundation received three Excellence in Economic Development Awards from the International Economic Development Council in fall 2008:

- » **Entrepreneurship**, for its work in recruiting and retaining high-tech startups
- » **Partnerships with Educational Institutions**, for the foundation's ongoing partnership with Purdue University, particularly in technology transfer
- » **Technology-Based Economic Development**, for helping move technology from the laboratory to commercialization through its programs and services that assist new businesses. □

Continuing Our Quest Two hundred years since Charles Darwin's birth, some eighty years since Georges Lemaître proposed the Big Bang theory and Edwin Hubble's observations later supported the theory of an expanding universe. Forty years since Neil Armstrong conquered another part of our universe. A couple of decades since we've been able to see images from Hubble.

Great as those achievements are, they are but tiny stars when we consider the years and opportunities ahead. Building on these and countless other achievements, we'll continue our quest for discovery and the search for new knowledge that can be shared for the greater good of humanity. The universe awaits us.

2008:2009 Office of the Vice President for Research
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