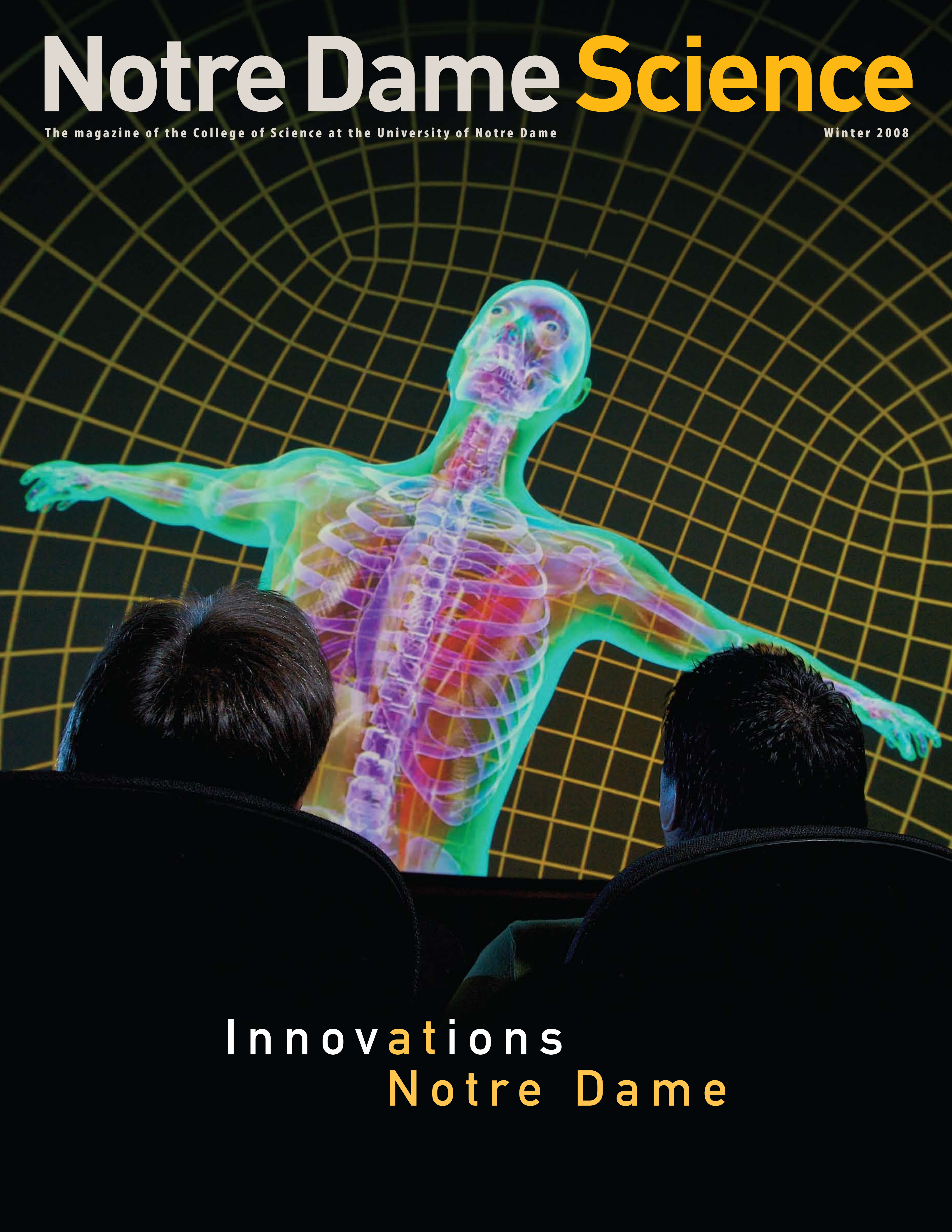
Notre Dame Science

The magazine of the College of Science at the University of Notre Dame

Winter 2008



Innovations
Notre Dame

Dean's Letter

I am deeply honored and grateful for the opportunity to begin leading the College of Science at the University of Notre Dame this year. I knew that I wanted to be part of this University because of its distinctive Catholic character, its overarching goal to do good in the world, its deep commitment to undergraduate training, its world-class faculty, and its record of collaboration, innovation and research—not to mention the premier undergraduate science facility in the world, Jordan Hall. The College of Science fosters a "think big" mentality, while affirming its unwavering commitment to excellence in undergraduate education, research, and service. I am excited to move this remarkable college forward.

The plan that I bring for our future is based on three key principles—growth, new relationships, and innovative interactions within the college, the University, and beyond. We will continue to find ways to move basic science ideas and discoveries forward, engaging individuals, organizations, and institutions. In particular, we will play an important role in the rapidly evolving Innovation Park at Notre Dame to help faculty and students find avenues to accelerate their discoveries and inventions to the marketplace. We will also expand our collaboration with the Indiana University School of Medicine. We will create industry-university relationships with both social and for-profit entities, potentially spurring economic growth in the South Bend and Michiana area and benefiting the global society with improved technology, healthcare, human services, environmental understanding, and more.

The vision for accomplishing these goals includes implementing the most advanced science, technology, engineering, and mathematics (STEM) approaches to education, encouraging and supporting faculty to adopt Socratic teaching, peer instruction, studio teaching, and other methods that reinforce our commitment to undergraduate education. I also want to capitalize on our connections with science alumni who have made significant accomplishments as scientists and professors, physicians and surgeons, business professionals, entrepreneurs and philanthropists. As you will see in this issue of *Notre Dame Science*, this is an exciting time of innovation for the College of Science.

I take on this important responsibility with great energy and enthusiasm, strengthened by the confidence my new colleagues and the administration have in my leadership capabilities and vision for the college. I truly resonate with the mission of the University of Notre Dame and especially that of the College of Science.

Sincerely,

Gregory P. Crawford
William K. Warren Foundation Dean
College of Science

About the cover:
The Digital Visualization Theater (DVT), which allows students to visualize and interact with a vast variety of information, is a great example of the innovative facilities at Notre Dame. The 50-foot-diameter domed theater immerses viewers in a 360-degree visual experience. Read more about the DVT in the Innovations in Teaching story on page 13.

Notre Dame Science was previously known as *Renaissance*, the journal of the University of Notre Dame College of Science. We welcome your feedback. You may contact us at **science@nd.edu**.

UNIVERSITY OF NOTRE DAME
College of Science

Notre Dame Science is published twice per year by the University of Notre Dame College of Science. Dean: Gregory P. Crawford; Editor: Marissa Runkle; Associate Editor: Bill O'Hayer; Writers: Gene Stowe, Bill Schmitt; Image Coordinator: Cheryl Kelly.

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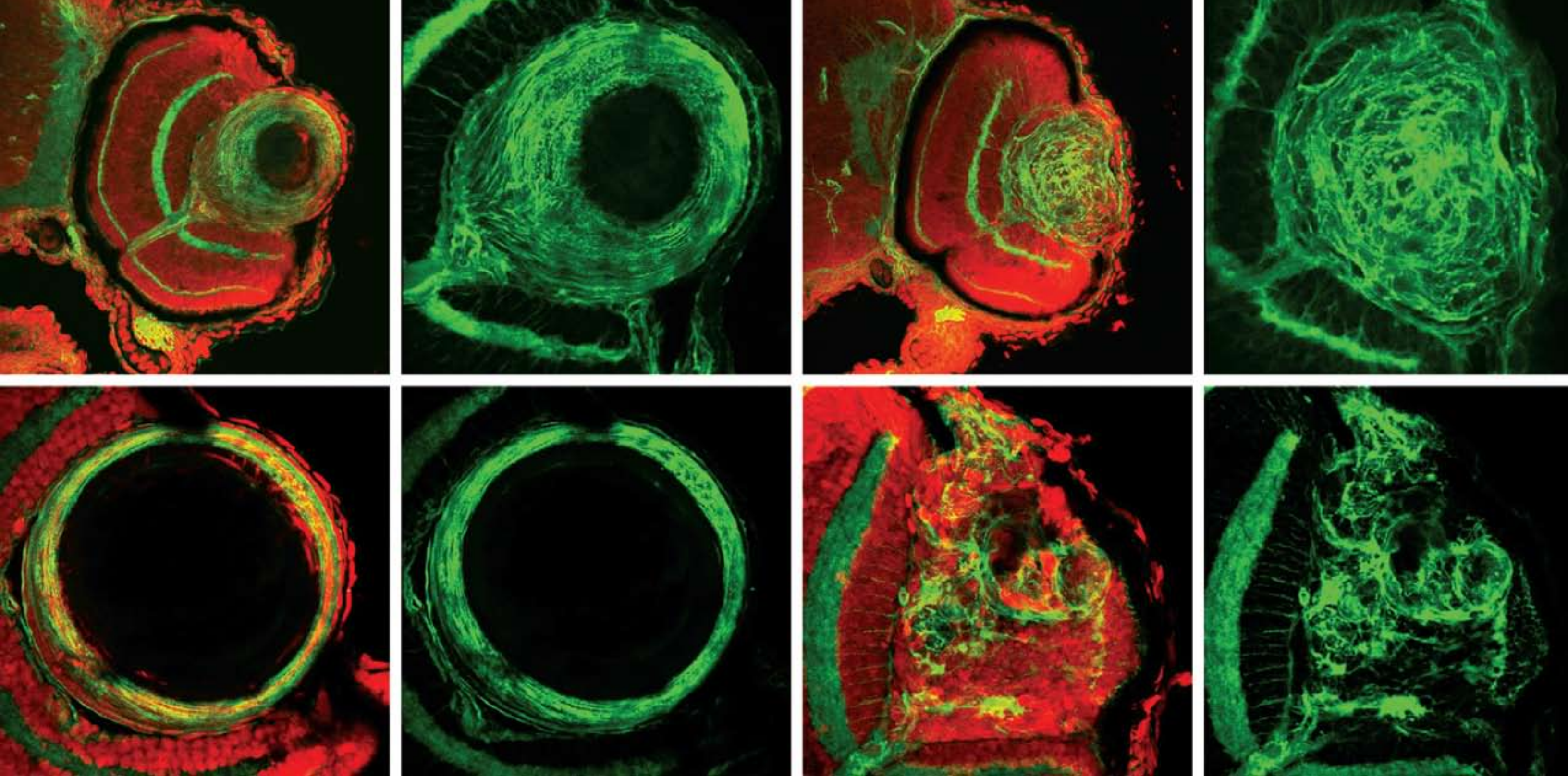


Notre Dame Science

The magazine of the College of Science at the University of Notre Dame Winter 2008
previously known as *Renaissance*

Contents

Above image: *Actin expression in the wild-type and mutant zebrafish lens and retina (Jake Montgomery and David R. Hyde, Notre Dame Integrated Imaging Facility).*

Joseph Marino helped to build the foundation for the next generation of innovation and discovery at the College of Science.

Tribute to **Joseph Marino**

THIS SUMMER, Joseph Marino ended six years as dean of the College of Science and returned to the life of a chemistry professor at Notre Dame. The legacy from Marino's term as dean is a cause for celebration and gratitude.

Notre Dame Science asked a number of his colleagues to recall highlights of strides that the College of Science made under the leadership of Dean Marino. The college and the scientific disciplines at Notre Dame have grown in size and stature—in their services to researchers, teachers, and learners alike—and in their ability and availability to make important contributions to the entire campus and the world. The college is now a better place for research, instruction, professional aspirations, and collaborations.

A Place for Research and Instruction

- Research expenditures consistently grew over 10 percent per year during his term.
- In FY 07, the college was awarded $44 million in research funds, representing 53 percent of the University's total research awards. Charles Kulpa, chair of the Department of Biological Sciences, recalled, "Joe always supported our efforts to increase our research activities while maintaining the excellence of our undergraduate and graduate programs."
- Mitchell Wayne, chair of the Department of Physics and former associate dean of undergraduate studies, commented, "He and the college made some excellent hires—some really high-profile people."
- The college began an annual event spotlighting and encouraging undergraduate research, noted former Associate Dean of Research Joseph O'Tousa. This helped to inspire younger students. Now, the college has a coordinator for undergraduate research and offers a number of grants for summer undergraduate research and related travel.
- The number of science majors increased 18 percent during Marino's tenure as dean, adding 179 students to the college.
- The college began hosting an open house for early-admission students, recruiting some of the country's brightest young people to study science at the University of Notre Dame.
- Under Marino's leadership, the Jordan Hall of Science opened in the fall of 2006 as one of the best facilities for undergraduate science instruction in the nation.

A Place for Professional Aspirations

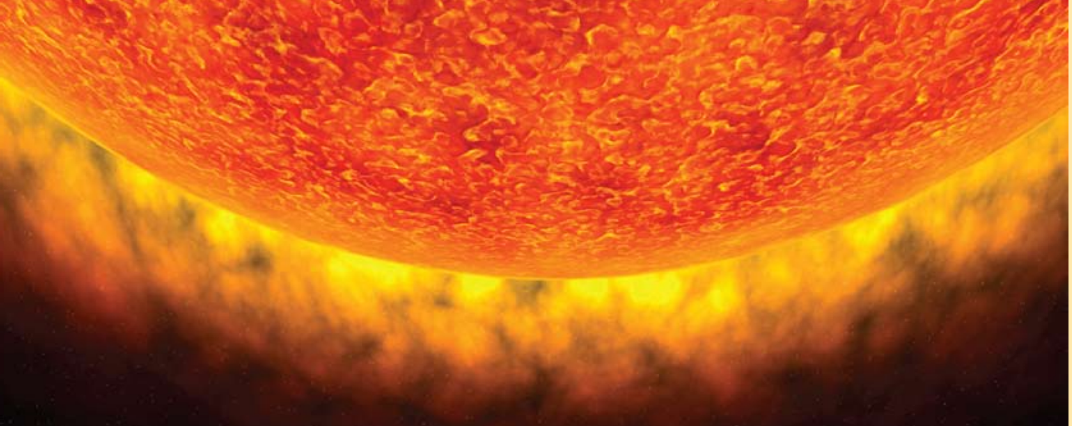
The Center for Health Science Advising, directed by Rev. James Foster, C.S.C., M.D., was created under Marino's watch to assist with the complex advising and medical school application process. The number of Notre Dame students applying to medical schools has increased, with the acceptance rate averaging 80 percent over the past five years, compared to the national average of 44.8 percent (2007). The center is one way in which the College of Science has guided all students applying to schools in the health professions, regardless of major. Marino has been strongly supportive of educating each student as a whole person, with sound ethics and a well-rounded perspective, says Foster. Such people, once trained as doctors, will "take care of the whole patient," he points out. Marino also has been "very supportive of students who are interested in the health professions"—including dentistry, veterinary medicine, pharmacy, and the allied health professions, says Foster. Growing numbers of students are expressing interest in these fields, as well.

A Place for Collaboration

The number of centers and institutes within the College of Science grew with Marino at the helm. The Interdisciplinary Center for the Study of Biocomplexity, the Center for Complex Network Research, the Center for Aquatic Conservation, and the Institute for Theoretical Sciences (attracting an international pool of top researchers to work at Notre Dame and the Argonne National Laboratory) are among the newest drivers for collaboration among diverse people and places.

Wayne, chair of the physics department, says he learned a lot working with Marino. The dean was consistently "concerned about what he felt was best for the University," he recalls. "Joe really cares about Notre Dame."

Joseph Marino helped to build the foundation for the next generation of innovation and discovery at the College of Science. The college is indebted to him for his leadership over the past six years.



Empowering Projects for Energy Innovation

THREE RECENTLY ANNOUNCED CROSS-DISCIPLINARY FUNDING COMMITMENTS are bolstering science and engineering research on sustainable energy.

This funding comes at a time when sustainability is in the campus spotlight, after the 2008 Notre Dame Forum on sustainable energy. All three projects are receiving seed funding from the Energy Center, a three-year-old organization based in the College of Engineering that taps into expertise from many scientists and others to develop technological answers to the global energy challenge.

"It was interesting to see that the three winning proposals all involve aspects of converting solar energy into more usable forms" said Prof. Joan Brennecke, director of the Energy Center. "Obviously, the researchers recognize this as an area with many significant technical challenges and opportunities."

The first project explores converting light into chemical energy using transition metal oxides. Three professors—Steven A. Corcelli, assistant professor of chemistry and biochemistry; Kathie E. Newman, professor of physics; and William F. Schneider, associate professor of chemical and biomolecular engineering—are seeking to develop accurate and computationally efficient models that will predict chemical reactions at the solid-aqueous interface.

It is quite possible such models could one day provide guidance for researchers in the second project, which aims to advance hydrogen production using solar energy to split water. Prashant Kamat, professor of chemistry and biochemistry, is working with Paul J. McGinn, professor of chemical and biomolecular engineering, to pursue more efficient photocatalysts for solar hydrogen production. This would allow for more widespread use of fuel cells, which have vast potential as a clean, efficient source of transportable, stored energy. McGinn is serving as interim director of the Energy Center while Brennecke is away during this fall semester.

The third project tackles another aspect of efficient use of solar energy, as it involves an investigation of the use of semiconductor nanostructures for capturing and using solar energy. This research team—Masaru (Ken) Kuno, assistant professor of chemistry and biochemistry, as well as Kamat—wants to grow conductive substrates for a new generation of solar cells. Photovoltaics made of low-dimensional materials could lead the way to low-cost, high-efficiency solar energy conversion.

Funding totaling more than $113,000 went to these three projects in 2008 from the Energy Center's new Seed Fund Program. The program was designed to support innovative, early-stage research projects that address energy-related issues and could lead to externally sponsored research projects. A goal of the center is to nurture projects like these three, which complement research work already being done at Notre Dame and which could attract outside funding at a later stage.

Find out more about the Energy Center at **energycenter.nd.edu.**

Dean of the College of Science Greg Crawford enjoys driving the BP solar utility vehicle (SUV).

In mid-August, College of Science Dean Greg Crawford was excited to receive a solar utility vehicle (SUV) from BP America, Inc.—one of the largest investors in alternative energy. BP's donation supports Notre Dame's commitment to the environment and to finding alternative sources of energy.

The solar vehicle is one of the most powerful all-terrain vehicles in its class. With 30 horsepower and over 170 pounds of torque, it is almost seven times more powerful than the average electric golf cart. BP Solar's 185 watt, photovoltaic solar panel augments the vehicle's battery charging system, giving it more operational range.

BP Alternative Energy, which was launched in 2005, combines all of BP's interests in wind, solar, hydrogen power with carbon capture and storage, natural gas-fired power generation, biofuels for low carbon transport, and distributed energy for emerging markets.

Several faculty members from the Notre Dame Energy Center are actively pursuing ways to increase the efficiency of alternative sources of energy, including solar power.

Cardiologist Vince Friedewald, M.D., in the Center for Health Sciences Advising, was instrumental in securing the donation.

The college has big plans for using the vehicle. In the meantime, Dean Crawford is looking forward to more sunny days.

bp

Innovative Directions for Science and Technology

THIS IS AN EXCITING TIME at the University of Notre Dame. The stage is set for Notre Dame to become a leader in innovation and discovery. There are new funding sources; new science and engineering buildings; a new consortium for nanotechnology discovery; a new technology incubator; a new cancer research facility in the works; and four new visionary leaders in science, engineering, research, and innovation.

Far left: New facilities such as the Digital Visualization Theater enhance instruction throughout disciplines. *Near left:* New funding sources have created the Notre Dame Imaging Facility and increased undergraduate research opportunities at UNDERC.

These four innovators—the dean of the College of Science, the dean of the College of Engineering, the vice president for research, and the director of Innovation Park—are part of Notre Dame's launch toward a new level of research.

Focused on solving the world's toughest problems in global health, energy, environmental sustainability, and numerous other challenges, researchers are becoming more interdisciplinary. Organizations, facilities, and funding mechanisms are emerging, with clearer commitments to goals and priorities. Most importantly, these

His cutting-edge research includes liquid crystal and polymer physics; these and other aspects of his basic and applied work have implications in photonics, displays, nanoscience, and biomedical devices. At the same time, Crawford has been an award-winning teacher; he developed a course to encourage undergraduate and graduate students to think entrepreneurially about applications of their knowledge that would impact society. Excellent teaching and an unsurpassed educational experience for undergraduates are inseparable from research, he says, as components of Notre Dame's vision for the future.

left: Jordan Hall of Science

below: Gregory Crawford

developments are attracting and engaging world-class individuals whose talents and ideas align with their enthusiasm for problem solving and a spirit of cooperation transcending specialized silos.

Gregory Crawford, dean of the College of Science, says his early visits to the campus revealed the "bigger sense of purpose" that permeates the institution—the desire to help solve some of humanity's biggest challenges. He saw "extraordinary people and extraordinary programs" embodying the University's distinctive mission and filled with potential for meaningful interaction: "I really wanted to be engaged in that kind of environment."

Collaboration may be a word that sums up Crawford and the direction in which he will take the College of Science. His career is a case study in building collaborative partnerships. He holds a Ph.D. in chemical physics, a master's degree in physics, and a bachelor's degree in physics and mathematics. He most recently served as dean of engineering at Brown University and professor of physics and engineering. Before joining academia as a member of the Brown faculty in 1996, he was a member of the research staff at Xerox Palo Alto Research Center (PARC) and a postdoctoral research associate at the Naval Research Laboratories in Washington, D.C.

Notre Dame Provost Thomas G. Burish, in announcing Crawford's appointment to a five-year term as dean and to a tenured position on the physics faculty, mentioned his unbounded energy, passion for science, and creative leadership style that makes him an ideal leader. Crawford says he wants to facilitate cooperation not only among the college's departments, but also between the college and all of the University's colleges and schools. "I will engage deans and faculty members in other colleges and identify new areas of interdisciplinary research to which we can make big contributions."

Even before his official arrival on July 1, Crawford began an ongoing dialogue with the College of Engineering, the Mendoza College of Business, and the College of Arts and Letters, which he expects to yield major results.

Peter Kilpatrick, dean of the College of Engineering since January 2008, earned a bachelor's degree in chemistry before receiving his Ph.D. in chemical engineering. Building his reputation as a teacher and researcher at North Carolina State University, where his research on fossil fuels helped improve energy efficiency and minimize environmental impact, he rose to be N.C. State's chair of chemical and biomolecular engineering.

right: Peter Kilpatrick

below: Stinson-Remick Hall

Now at Notre Dame, Kilpatrick joins Crawford in affirming the University's commitment to outstanding teaching alongside excellent research and scholarship, all designed to enrich undergraduates, graduate students, faculty members, and the wider world. Both deans are eager to support interdisciplinary collaborations, taking the form of teams where people with deep, specialized knowledge can share their expertise broadly to address some of humanity's most difficult challenges.

"The easy problems have all been solved," says Kilpatrick. "It's just very natural that the kinds of problems that scientists, engineers, and technologists are pursuing are getting more and more complex," so they have to work together. Notre Dame's Catholic mission also promotes an approach to research that is integrative rather than "reductionist," he points out.

In the near term, these interdisciplinary research teams are being formed to address such complex problems.

The College of Engineering's new Stinson-Remick Hall, promises to be another quantum leap for Notre Dame's infrastructure of innovation.

One of the items on both deans' longer-term agendas is the construction of a building dedicated to interdisciplinary research. It would house facilities for the work that both colleges do in key areas of focus, such as energy, the environment, and life sciences. It would also help to build bridges, Kilpatrick says, between the engineering research that tends to be at the molecular or nanoscale level and the biological research that tends to be at the organism level.

In a key organizational change, Notre Dame restructured its governance of graduate education and the research enterprise last year when research was split off from the former position of vice president for graduate studies and research.

The new position of vice president for research, reporting directly to the provost, is held by **Robert J. Bernhard**, who had been associate vice president for research and professor of mechanical engineering at Purdue University. In the announcement of his appointment, Bernhard said Notre Dame's goal to embrace and enhance the trio of research, teaching, and Catholic character is "personally exciting to me."

Robert J. Bernhard

The pursuit of research preeminence was ramped up last year by another new organization whose members include Bernhard, Provost Burish, and Executive Vice President John Affleck-Graves, along with representatives of the University's colleges. The Strategic Academic Planning Committee (SAPC) began a major new initiative to advance research at the University. In May 2007, the committee invited all faculty to submit proposals suggesting research projects in which Notre Dame could invest. University Trustees budgeted an initial $40 million of support for a first round of projects deemed most promising.

A second round of proposals with similar funding has been invited. Simply bringing together diverse groups of experts to submit these proposals has enhanced the University's infrastructure for innovation. It is fostering collaborations that may also be eligible for external funding and could make a difference for the world. More directly, this approach is encouraging the Notre Dame community "to think broadly about what's possible," says Dean Crawford.

"From the proposals that were funded this year, you can see the cross-pollination between colleges, departments, faculty members, and students," he says. Two of the five proposals chosen for the first round of funding—on global health and advanced imaging, respectively—are based in the College of Science. Two more incorporate the scientific disciplines among the experts they have assembled. (See Strategic Research Initiatives article on page 20.)

PROMOTING INNOVATION: PATENTS IN THE COLLEGE OF SCIENCE

Madison Building on the U.S. Patent and Trademark Office campus

The U.S. Patent and Trademark Office promotes innovation by granting patents and registers trademanks that serve to protect the intellectual property rights of diligent, hard-working inventors. Across the College of Science, 18 patents are currently pending as utility patent applications; eight have been filed as provisional patent applications; and 17 have been issued and remained active since 1995.

Shahriar Mobashery, the Navari Family Chair in Life Sciences, has filed two patents on novel antibiotics within the last year. Professor of Chemistry and Biochemistry Paul Helquist was issued two patents relating to orphan drugs, one on new antibiotics and another on methods to produce new catalysts for use in the production of pharmaceuticals. Professor of Chemistry and Biochemistry Marvin Miller has three provisional patents and four issued patents for technology in the area of fighting tuberculosis, cancer, and multi-drug resistant bacteria.

The office of Technology Transfer at the University of Notre Dame provides guidance in commercializing these inventions and numerous others. When the University elects to pursue a patent, it bears the cost of pursuing the patent, owns the rights to the patentable invention, and shares the invention revenue with the faculty member.

Collaborations with the corporate world and the local community are additional examples of the waves of change sweeping through the University. The premier example is Innovation Park at Notre Dame, a joint project between the University, the city of South Bend, and a regional economic development organization called Project Future. Innovation Park, a technology incubator center, due to be constructed by 2009, will bring local professors, students, other researchers, and business entrepreneurs together to commercialize new applications of science, engineering, and technology.

David Brenner, a 1973 Notre Dame graduate, took the helm as director of the Innovation Park project at the start of this year. Brenner expects start-up ventures to stay in the park from a few months to a couple of years.

One strong connection in this very tangible infrastructure for collaborative innovation is a new nanotechnology research consortium that will be led by the University. The consortium, called the Midwest Institute for Nanoelectronics Discovery (MIND), also includes distinguished partners like Purdue University, the University of Illinois, the University of Michigan, Argonne National Laboratory, and the National Institute of Standards and Technology. It will receive financial support of more than $25 million from private and public sources, as well as from Notre Dame.

MIND is expected to catalyze future investments and to tie Notre Dame closely to local and state economic initiatives.

Businesses of all sizes understand the value of interdisciplinary work, realizing they need people with many different skill sets to generate and implement new ideas for the marketplace, says Dean Crawford. He participated in collaborations involving chemists, physics, and engineers while working on liquid crystals at Xerox PARC. "Corporations understood this long ago," he says, adding that "it was natural for me."

David Brenner

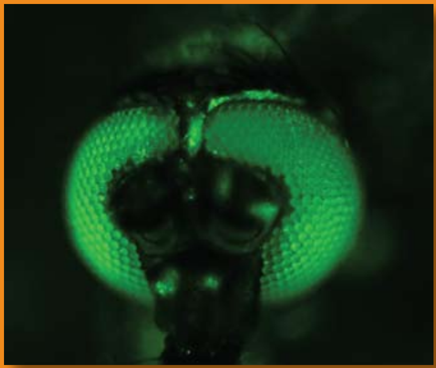
Overall, the College of Science is home to more than a dozen centers and institutes that represent an ever-widening circle of collaboration.

DISCOVERING THE PIGGYBAC TRANSPOSON

A transposon discovered more than a decade ago by Malcom Fraser, professor of biological sciences, who named the jumping gene piggyBac, is proving broadly useful for genetic engineering of a variety of organisms. Fraser has four patents issued and two on file. He began his work with baculoviruses in the early 1980s and identified piggyBac first in the cabbage looper moth.

Transposons are segments of DNA that can move around within an organism (hence the nickname "jumping") and cause mutations. That mobility and their ability to carry other genetic material make them useful for introducing new material into target organisms. Their viral behavior makes the introduction rapid and widespread. The piggyBac transposon, unlike most other transposons, is not limited to movement within its own host species but can move in the genomes of other eukaryote organisms.

Researchers some 10 years ago successfully used piggyBac to perform a genetic transformation of an insect, the Mediterranean Fruit Fly, for the first time. The study showed that the change was maintained through 15 generations. Since then, many other insects have been genetically engineered using piggyBac. In 2005, researchers in China used the transposon successfully in manipulating the genome of mice and showed that it can insert itself into the human genome. Fraser says applications could range from fibers to human therapeutic proteins to vaccines. He says, "We believe that these properties can be exploited for an even broader range of invertebrate species, and perhaps even vertebrate species, and are hopeful that more attempts will be made to utilize the element for transgenic studies."

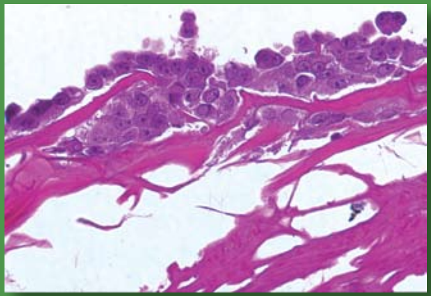


Eyes of a killer: transgenic Aedes aegypti *fluorescent eyes, transformed with piggyBac*

Innovation Park

"An emerging trend in the world and at Notre Dame is this thing called cyber-infrastructure," says Gregory Madey, a member of the Computer Science and Engineering faculty who is on the executive committee of the Interdisciplinary Center for Biocomplexity. "To the degree that Notre Dame scientists' desires for collaboration might have been hobbled before by geographical distance from centers of research in their specialty, computer connectivity is increasingly making distance irrelevant." Collaborative work is made easier by such computer tools as advanced video for observing experiments in progress, downloads of data from remote sensors around

DEVELOPING A PATENT ON A PROSTATE CANCER VACCINE



Cancer cells prior to processing into vaccine formulation

Director of the Freimann Life Sciences Center, Mark Suckow has six patent applications pending related to vaccines and expects the first to be issued by the end of this year. The approval process takes four to five years. All of the intellectual property has been licensed from Notre Dame by a medium-sized company that already has products on the market. "The company's goal is to commercialize at least some of the technology derived from Dr. Suckow's laboratory. They are especially excited about the vaccine adjuvant technology," Suckow said.

Suckow, who has been researching vaccines for some 20 years, was focused on infectious diseases before he came to Notre Dame 10 years ago and started working with a prostate cancer model developed by internationally recognized prostate cancer researcher Morris Pollard, director of the Lobund Institute. He focuses on two main technologies—one related to cancer vaccines and one with vaccine adjuvants, substances used to help make vaccines work even better. The patent applications involve nuances of each technology.

His approach with cancer is to develop a vaccine that uses targets expressed directly in tumors rather than from cultured cells. "My approach has a huge menu of such targets, compared to other vaccines, which have greatly fewer," Sukow says. The vaccine has been shown in animal models to help prevent prostate cancer, with a 90 percent reduction in incidence, and to treat prostate cancer, with a 20 percent cure rate and 70 percent reduction in the number of individuals having metastasis.

the world, and the wiki phenomenon, in which multiple people contribute to the same dialogue or report. "Virtual organizations" are forming to connect experts around the world, and "collaboratories" emulate a shared laboratory experience, says Madey. "It's gotten easier for me to work with people around the world." This innovative direction will help Notre Dame to overcome constraints that have more to do with distances than disciplines. "We're starting to play in the major leagues here," Madey says. "It's going to change the way we work and do research—and teach, for that matter."

The capabilities of the computer notwithstanding, the most effective forces driving science in innovative directions at Notre Dame are still the impacts of people, perspectives, and places, says Dean Crawford.

"I find Notre Dame to be just a fascinating place," he says, pointing to the potential synergies that have arisen among different departments and schools, among the people and projects there seeking broader knowledge and better answers through cooperation, and between academe and the business and government sectors.

Regarding resources more narrowly defined, Crawford points to places like the Jordan Hall of Science as "nothing short of spectacular." He has never seen "any teaching facility of that scale and that quality." It's an inspiration for collaboration and creativity, he says. "When you walk in, you feel like you want to invent and discover."

The College of Engineering's new Stinson-Remick Hall, due to be completed by late 2009, promises to be another quantum leap for Notre Dame's infrastructure of innovation. Its features will include a nanotechnology research center, a new home for the Notre Dame Energy Center that develops next-generation energy technologies, a semiconductor processing and device fabrication clean room, and an interdisciplinary learning center for undergraduates.

But even more impressive than the buildings is the presence of motivated people and the potential for them to make a difference—just as Father Jenkins has envisioned. Crawford says he personally wants to help redouble that phenomenon. "We will create ways for people to meet and innovate," says Crawford. He has seen collaboration bear fruit in many ways in companies, on campuses, and within communities, but it's only the beginning.

Innovation Park: innovationparknd.com
Eck Institute for Global Health: nd.edu/~cghid
Notre Dame Imaging Facility: nd.edu/~ndif

USING A MATHEMATICAL METHOD TO PREDICT BREAST CANCER RECURRENCE

Patients diagnosed with breast cancer are normally treated with surgery, radiation therapy, chemotherapy and possibly hormone therapy, although many will not relapse even without chemotherapy.

Professor of Mathematics and associate dean for undergraduate studies Steven Buechler has developed a way to predict the recurrence of breast cancer using network theory and microarray data. A provisional patent on the method has been filed. The tool, taking advantage of research into the molecular biology of cancer cells, can guide individual treatment plans, perhaps avoiding chemotherapy when it provides little benefit.

Buechler's work provides a new way of selecting genes for a test that predicts the recurrence rate of breast cancer. His approach is more stable and more accurate than previous methods. It uses the expression level of only four genes to predict relapse or define disease subtypes, making more targeted treatment possible. The method, which can be applied to all estrogen receptor positive tumors, has been validated in six independent datasets with different clinical traits and technical formats.

The method can also be applied to other types of cancer and may spare many patients from expensive, unnecessary chemotherapy and its associated side effects.

Innovatio

THE MANDATES ARE CLEAR. Dean Gregory Crawford says he is committed to achieving Notre Dame's goal to "be a premier research university and to have the best undergraduate programs and teachers in the country." The guidance of Blessed Basil Moreau, founder of the Congregation of Holy Cross, has echoed across the campus, recalling this community's spiritual mission to "educate the heart and mind," one person at a time.

The use of the DVT is predicted to grow as research grows, because visual information garnered from research can often complement teaching.

What do those mandates imply for the future of teaching in the College of Science, which, like Notre Dame's other colleges, has already built a reputation for extraordinary pedagogy? In recent

ns in Teaching

Chemistry professor Dan Gezelter stimulates students' curiosity through flashy experiments like this one in which he ignites a mixture of boric acid and methanol in the shape of a shamrock.

interviews, faculty offered glimpses into their classrooms and laboratories, showing that their styles have different emphases but a shared use of innovative instructional methods and resources.

One sign of innovation is the recent redesign of the first two years of the chemistry curriculum, prompted largely by the recognition that "the students at Notre Dame were capable of handling organic chemistry much earlier," says Associate Professor of Chemistry Dan Gezelter. The curriculum now starts with a one-semester general chemistry course. "We need to cover an enormous amount of material and make sure all the students are ready for the first semester of organic chemistry, even though the chemistry background of the first-year students spans a wide range."

Part of the response to this challenge is technological. Students submit homework online. Also, Gezelter carries a tablet PC with him in his 250-student classroom and, after posing a problem to the whole class, he will pick a student at random to "show me what they've got" by writing on the tablet. The writing—a student's solution to a particular problem, perhaps the depiction of a particular molecule—is displayed on a projection screen for the whole class. Other students can immediately disagree and suggest alternative solutions. "There's a little bit of an edge of competition," Gezelter says, adding that he never aims to make individuals feel uncomfortable. "The main goal is to keep them interested and engaged with the material."

Another way to keep a high level of engagement has nothing to do with computers. "I do as many loud, smelly, noisy demonstrations as possible," Gezelter says with a smile. Besides capturing attention, such opportunities to see textbook facts come alive in a spectacular chemical reaction help to present facts in different ways for different types of learners.

"Being a spectator isn't enough to keep up with a fast-paced introduction to college chemistry," he says. There is plenty of homework. Graduate student teaching assistants run a drop-in center for homework help. During tutorials, undergraduates break into small groups, and each member in turn plays a teaching role, explaining a subject to classmates. "We do everything we can to make sure that the first-year students leave the first semester with the background they need for organic chemistry," says Gezelter.

A tablet PC allows Malgorzata Dobrowolska-Furdyna to write on the screen, while facing students who respond using hand-held "clickers."

Malgorzata Dobrowolska-Furdyna, professor of physics, agrees that students learn best by doing rather than simply reading or watching. That's one reason why she requires each student in her introductory physics courses to buy a clicker (much like a TV remote control) that communicates via radio waves with her computer, whose display is projected for the whole class to see. Using the device, the class can respond to multiple-choice conceptual questions and take quizzes.

The quizzes also confirm that students have completed their assigned reading before class starts. Results from the quizzes also make teaching more efficient, because, she says, "I focus on what they don't know." Dobrowolska-Furdyna uses a tablet PC with a projector so that she can write formulas "on the board" without turning away from the class. She also uses animation to help students visualize, for example, what happens to the path of an electron in the presence of a magnetic field.

Her embrace of technology came after years of more traditional lecturing, she says. "I imagined that if it was fun for me, it would be fun for the students." But she adds that students have to go beyond answering multiple choice quizzes to actively thinking things through: "Solving problems is the ultimate test of understanding," Dobrowolska-Furdyna says. She likes to solve a sample problem illustrating a concept and then break students into peer-instruction groups where they discuss and defend their analyses of similar problems.

Mathematics professor Alex Himonas likewise has put an emphasis on solving contemporary problems among his calculus-for-business students. He says he has changed the way he composes examinations, allowing students to use calculators, but also probing to see if they think about a problem along a path that leads to the correct answer.

"Students come here to Notre Dame to be driven by big problems," Himonas explains, so he is happy to connect just about everything in the course to students' real-life experiences. He invites them to think about questions such as, "Are gas prices more a question of supply and demand or more a result of market speculation?" To encourage students to mull over the issues, he allows them to do much of their work via the course website, at a time and in a setting of their own choosing.

Sometimes the engaging context that gives a course an extra dimension comes not from the pressing questions of the present, but from enduring aspects of the past. Prof. Alexander Hahn, director of the University's Kaneb Center for Teaching and Learning, has seen many teaching innovations, and he praises many College of Science faculty members for high-tech contributions like the introduction of new software and low-tech contributions like maximizing availability through extended office hours. But one thing he likes to contribute to his own math students are behind-the-scenes glimpses at the people and ideas that have propelled major advances in mathematical knowledge.

Hahn's calculus course for honors students introduces them to ideas in the texts written by foundational figures in mathematics. He says the syllabus inquires, "What sort of math did Archimedes, Galileo, Kepler, Newton, and Leibniz actually engage?" For example, the students study Johannes Kepler's planetary mathematics and then see it in action within a computer model of the elliptical orbits of the planets. Hahn is also developing a course, "Mathematical Excursions to the World's Great Buildings," that Notre Dame's architecture students can take to satisfy their mathematics requirement. Through approaches like this, Hahn says, science students

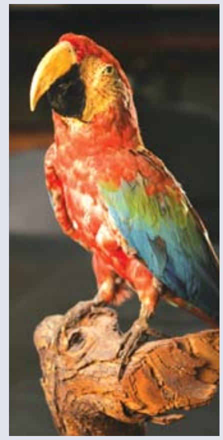
Mathematics professor Alex Himonas and graduate student Steven Broad have been working to make the first- and second-semester calculus courses available through Notre Dame's OpenCourseWare, a free and open educational resource for learners throughout the world. Notre Dame is part of the OpenCourseWare Consortium with over 200 institutions across the globe. ocw.nd.edu connect mathematics to their work in other disciplines, and students in other disciplines see the relevance of mathematics in the pursuit of their interests.

Thinking for oneself is often connected with seeing for oneself. Empowering students to visualize and interact with information is part of what makes the Digital Visualization Theater (DVT) in the Jordan Hall of Science such an important teaching tool, says DVT director Keith Davis. In problem-solving situations where there are billions of data points to be understood, "the best way to do that is to turn that information into something you see," he says. The visualization is not the end of the story. Rather, seeing the patterns and gaps in the information prompts further inquiry because one "sees things that are worth investigating."

The DVT is an outstanding teaching resource for the College of Science. While it is used primarily for astronomy and biology courses so far, Davis says he wants to see it used in all sorts of curricula, from architecture to film. He hopes to educate faculty members all around campus about how the planetarium-like theater might suit their purposes.

For the moment, he says, the sciences are the principal candidates for the facility. Its usefulness is bound to grow as research grows at the University—not because the DVT is, itself, a research tool, but because information garnered from research can be readily translated into forms that complement teaching. For example, data taken from a CT scan of an organism can be integrated into an anatomical model, then projected and studied close-up from multiple perspectives. Or an enzyme model that was

The Museum of Biodiversity



The Museum of Biodiversity is another part of Jordan Hall that is enhancing undergraduate education. Premium space on the building's first floor has been devoted to the museum, which is focused on teaching, not tourism. The new space allows sophisticated storage and display of Notre Dame's approximately 600,000 specimens (many virtually irreplaceable) documenting life in various forms from around the world.

The collections, including 300,000 preserved plant specimens that constitute the largest herbarium in Indiana, are valuable for research. But their principal use, facilitated by several laboratories adjacent to the museum space, is in the teaching of courses in plant sciences, general biology, vertebrate biology, ecology, entomology, parasitology, evolution, mammalogy, and other subjects.

"It's one thing for a student to look at a textbook illustration, but that's not the way specimens typically look in the field," says Ronald Hellenthal, professor of biological sciences and director of the museum. "Here, we can show a student what it is like to look at a human blood smear with an actual parasite."

Student excitement also springs from the museum's up-close connection to Notre Dame's scientific research of the past. The herbarium has specimens dating back to the late 1700s, thanks largely to Rev. Julius Nieuwland, C.S.C., a Notre Dame alumnus and distinguished faculty member in both biology and chemistry, who gave new life to the University's biology program in the early 1900s, says museum curator Barbara Hellenthal. "Father Nieuwland founded the [herbarium] collection and started using it immediately for students."

Michelle Whaley instructs biology majors Lexie Perreras *(left)* and Elizabeth Leuchtmann *(right)* in research techniques in the Molecular Genetics Laboratory.

developed for research purposes can be used to make others more informed and excited about the research prospects.

One of the key innovations emerging in undergraduate teaching today is indeed the close linkage with research. "The visualization is important because students seem to be more and more inclined toward that way of processing information," says Joseph O'Tousa, professor of biological sciences.

With encouragement that has grown during the past five years, undergraduates have generally come to think of research venues less as *terra incognita* and more as an inviting place for personal and team involvement. "The labs themselves have greater square footage and better lines of sight," O'Tousa says of spaces in Jordan Hall. Students can have a sense of ownership over their portion of the space and room for comfortable collaboration.

One of the key innovations emerging in undergraduate teaching today is the close linkage with research.

Michelle Whaley, of the biological sciences faculty, is teaching courses that immerse undergraduates into the research environment. For sophomores considering graduate study in the sciences, she offers a course that is essentially a semester-long research project in cell biology, culminating in poster presentations—and possibly even coauthorship of a peer-reviewed journal article, if students continue their research after the course. Other faculty members volunteer their time as mentors to these budding researchers, so they need not feel overwhelmed or directionless. Such research opportunities truly ignite enthusiasm in many students, prompting them to spend considerable time with great results academically and personally, says Whaley.

"They do their best work when they have the most control over the research," she notes. "The students truly amaze me every year. Their level of thinking and communicating becomes much more sophisticated." This research course is the maximum expression of a lesson that science professors have put into practice in other courses, too—namely, that laboratories are "not just a supplement" to enhance the lecture experience, as Whaley says. Today's labs are centers for teaching critical thinking and developing skills different from those nurtured in a classroom.

Nevertheless, the semester-long research project is not for everybody. Students considering a preprofessional track can opt for an "Introduction to Undergraduate Research" course that offers a broader and less immersive view of laboratory work. There is still hands-on research, Whaley says, but individuals also participate in the writing of research proposals and the reading and presentation of research articles.

Medical schools appreciate applicants who have demonstrated a hunger for new knowledge, says Rev. James Foster, C.S.C., director of the Center for Health Sciences Advising. This is usually done through lab-based research, although students also hope to benefit from opportunities with the College of Science's other health research units and increasingly with the clinical research facilities of the Indiana University Medical School–South Bend. Domestic and international service-learning experiences like those provided by the Center for Social Concerns, where a student sees health care practices up close, can also produce hands-on learning that changes lives.

Science faculty members agree that research and teaching are inextricably tied, especially in the formation of students who want to make a difference in the world through personal engagement. This has always been true in graduate programs, where faculty mentoring of graduate students is a powerful form of teaching. But it's increasingly true among undergraduates.

Research is part of the mix of learning experiences that tomorrow's leaders need—a mix that also includes lectures, discussions, demonstrations, peer instruction, real-life case studies like those used in business and law schools, and partnerships with those already connected to real-world issues and institutions, Dean Crawford says. Educators who are reaching beyond their own disciplines to do problem-solving research can heighten students' awareness of the possibilities—and of the mandates for excellence that are propelling Notre Dame.

Alumnus Directs Pain Management Research

Paul J. Christo, who graduated from Notre Dame in 1990 with a Bachelor of Science in Preprofessional Studies and from the University of Louisville School of Medicine, felt inadequately trained to help people in pain when he was a medical intern. Now, as director of the Pain Treatment Center and the Pain Fellowship Program at the Johns Hopkins University School of Medicine, his efforts focus on educating physician trainees about pain and investigating methods of helping patients more effectively control their pain through clinical research.

Christo's interest in research deepened after his anesthesiology residency at the Massachusetts General Hospital, which is affiliated with Harvard Medical School. During a fellowship year at Johns Hopkins, he focused on the clinical aspect of treating pain, including injection therapy, medication, and implantation of pain pumps and spinal cord stimulators.

"As part of our training in anesthesiology, we learned how to treat acute, perioperative pain," he says. "I still strongly felt the need to learn more and to gain the unique skills required for treating chronic pain. The fellowship year is focused on learning how to diagnose chronic pain conditions like low back pain and neuropathic pain, and how to treat them with a variety of medications, X-ray guided injections, and surgical implantations. I delved into the whole pain specialty. My mentors were researchers and clinicians."

Christo, who joined the Johns Hopkins faculty after he finished the fellowship year, spends about three-and-one-half days a week seeing patients and doing clinical work and one-and-one-half days on nonclinical jobs, including conducting studies. He has published his work 26 times in book chapters, case reports, and clinical journals; has presented at scientific meetings; and is on the editorial board of numerous journals. In addition, he recently earned an MBA from the Johns Hopkins Carey Business School.

Lately, he has been involved in clinical research that includes studying sexual function in chronic pain patients, the effectiveness of Botulinum Toxin (Botox) in treating Thoracic outlet syndrome, analyzing pain medication prescription errors among adult patients at the Johns Hopkins Pain Treatment Center, and assessing basic knowledge of pain medicine among healthcare professionals in the hospital setting.

"We understand that certain pain medicines may alter sexual function, but there is little detailed information about which ones, what doses, and the differential effects between men and women," Christo says. The study, with both male and female patients, involves all classes of medication prescribed in the pain treatment center. Early analysis seems to indicate an association between opioids and sexual dysfunction, with similar effects in both men and women, he says.

The Thoracic outlet syndrome study involves injecting Botox into the anterior scalene muscle of the neck, using a needle under computer tomographic (CT) guidance. Preliminary results suggest that the treatment may help provide more sustained relief from this condition. The pain prescription error study involves analyzing whether the wide range of drugs used to treat pain, often in combination, are being safely prescribed to outpatients. Errors could include dosage and frequency of administration. "More and more hospitals are focusing on establishing the safe delivery of medicines for patients in the hospital and for outpatients," Christo says.

Paul J. Christo

JOHNS HOPKINS
MEDICINE

For the study assessing the knowledge base of hospital health care professionals, Christo helped design a pain module—pretest, educational component, and post-test—for all involved in the clinical care of patients at Johns Hopkins. "I wanted to measure their level of knowledge of basic pain concepts, identify their deficits, and then develop strategies to enhance pain care for patients in the hospital," he says.

Christo's work ensures that other doctors will have greater knowledge and skill than he did at the beginning of his career. "When I was an intern, I was exposed to a great number of patients who suffered from chronic pain," he says. "I felt I didn't have the ability or the knowledge to ease their suffering. I think we've made progress, but we've only reached the tip of the iceberg."

UNDERC Selected as National Research Site

The National Ecological Observatory Network (NEON) has selected the University of Notre Dame Environmental Research Center's (UNDERC) land in northern Michigan and Wisconsin as a core site representing the upper Midwest. Sponsored by the National Science Foundation, NEON is a continental research platform for discovering and understanding the impacts of climate change, land-use change, and invasive species on ecology. Selection as a NEON site will double or triple education and research opportunities at UNDERC.

Notre Dame's 8,000 acres of northern hardwood forests, lakes, and wetlands straddling the Wisconsin-Michigan border will be part of a national network designed to measure environmental factors in areas that have not been disturbed by humans. In addition to regions across the continental United States, from New England to the Desert Southwest, NEON has two sites in Alaska, one in Hawaii, and one in Puerto Rico, for a total of 20 sites. Each site is chosen because it has environmental conditions most representative of the region, including typical vegetation, weather, and soil conditions.

"All the sites have to be wildland sites," says Gary Belovsky, director of UNDERC since 2001, "and must be protected from the general public. NEON is going to be coming in and building their research infrastructure." The goal is to develop a baseline of information about such environments that, among other things, will allow researchers to measure the effects of human activity in surrounding areas and patterns across the nation. The project will have federal funding for at least 30 years.

Every NEON site will have a tower with a series of sensors to gather data on climate, air quality, water quality, soil characteristics, and other environmental factors. Equipment also will collect data on soil and aquatic chemistry and track changes and patterns in small mammals, insects, birds, fish, soil microbes, plants, and algae. The national study includes the seven environmental "grand challenges" identified by the National Research Council—biodiversity, biogeochemical cycles, climate change, hydroecology, infectious disease, invasive species, and land use. The standardized measurements will be available in real time on the Internet for downloading almost as quickly as they are collected. NEON also will provide a staff of three to five people at each site, including a faculty-level scientist, a technician, and probably an environmental education specialist. Depending on facilities already present, NEON may construct additional laboratories and housing. UNDERC currently has housing for about 120

Each summer, about twenty-five undergraduate students conduct their own field research in environmental biology at UNDERC-East, located in the Upper Peninsula of Michigan. The site encompasses more than 7,500 acres with abundant wildlife including deer, wolves and black bear.

Above: **Bay Lake is one of 30 lakes, streams, and wetlands that have been protected for centuries. After completing 4–5 one-week instructional modules on field biology including bird/mammal ecology, amphibian/reptile ecology, aquatic ecology, or other topics, students can conduct their own investigations under the guidance of a faculty member or graduate student.**

people, research labs, teaching labs, and classrooms already on the site. Notre Dame has owned the property since the early 1950s and held summer classes for undergraduates on the site since the 1970s. At the Michigan site, the number of summer undergraduate researchers has grown to 24, while the number of graduate student researchers has increased to more than 15.

UNDERC opened a western site in Montana in 2006 and a southern site in Puerto Rico in 2008. UNDERC-West involves eight students (half of whom are American Indians) each summer on 1.6 million acres of the Confederated Salish and Kootenai Indian reservation. UNDERC-South has two students each summer who conduct rain forest research at the El Verde Forest Research Station.

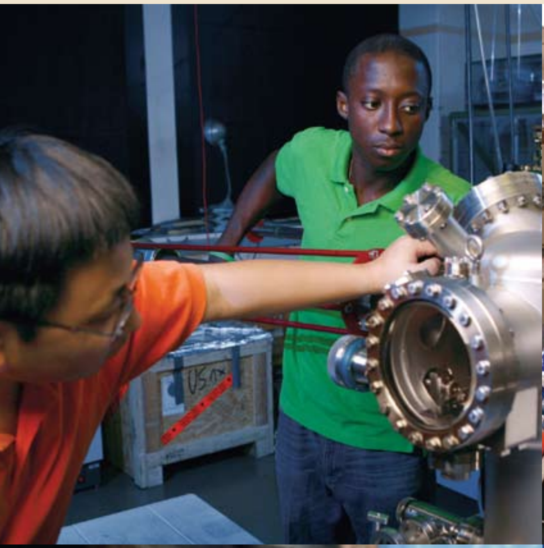
Strategic Research Initiatives
bring new funding to integrated research

IN JANUARY 2007, UNIVERSITY PROVOST Thomas G. Burish announced the creation of the Strategic Academic Planning Committee (SAPC), a major new initiative to advance the scope, excellence, and visibility of the University's research enterprise. In May 2007, the committee invited all faculty to submit proposals suggesting research projects in which Notre Dame could invest. University Trustees budgeted an initial $40 million of support for a first round of projects deemed most promising.

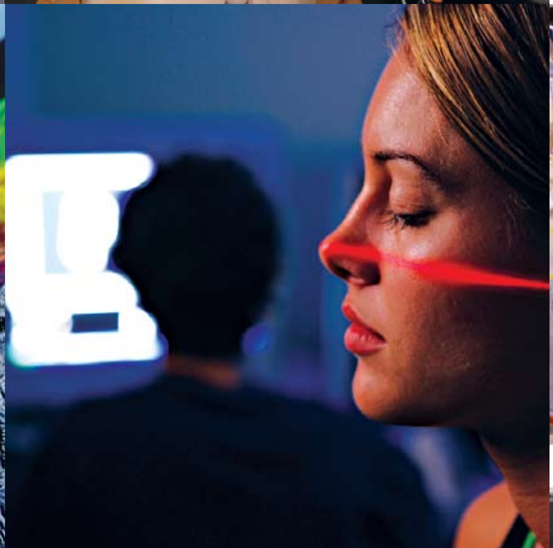
SAPC (pronounced sap-cee) received an unexpected 72 proposals for interdisciplinary research in its first round. A second round of proposals, which will be funded at another $40 million, has been invited. Simply bringing diverse groups of experts together to submit their proposals has created a dialogue that is extremely valuable. The process itself has enhanced the University's infrastructure for innovation.

This is a commitment of a total of $80 million in internal financial resources to support the first two phases of integrated research initiatives. In the first phase, five initiatives are being funded up to $40 million. Two of the five projects are based in the College of Science, while two additional projects will incorporate the expertise of science faculty.

"SAPC funding is an important new asset in attracting top-flight scholars and students."
—Bob Bernhard, Vice President for Research








David Severson and Jeffrey Schorey

GLOBAL HEALTH

One of the two SAPC initiatives based in the College of Science will build upon the work of the Eck Institute for Global Health.

The institute aims to promote development of drugs, vaccines, and novel pesticides by better understanding disease-causing pathogens and the insects that carry them. Notre Dame received a $20 million gift from the estate of alumnus Frank E. Eck in early 2008 to support the institute's expansion of more than five decades of research on infectious diseases, such as malaria, that claim many lives, especially in underdeveloped countries.

Now, the SAPC support—the first infusion of major, targeted support from internal University funding—will bolster the growth of core capabilities in bioinformatics and genomics, says Frank Collins, a leading researcher in the institute, its former director, and the George and Winifred Clark Chair in Biological Sciences. The two capabilities are linked because the huge quantity of data inherent in genomic analysis requires the sophisticated computational science of bioinformatics, Collins explains. Those capabilities, in turn, can complement the work of many other biological and biomedical researchers on campus.

"These are resources that can be used University-wide by people in the institute, as well as by people not affiliated with the institute," says Assistant Director Jeffrey Schorey, associate professor of biological sciences. "One of the strengths of Notre Dame relative to a lot of medical schools is that you can find many people whose work here touches upon global health but in very different venues."

Schorey and the institute's new director, David Severson, envision the SAPC funding helping the Eck Family Center to offer more of the kinds of resources that will spur new inquiries, new external grant opportunities, and new collaborative projects among a wider array of faculty, staff, and students. The impact on students is an important SAPC dividend, says Collins: "It's not just research to solve world problems, but it's also research to give the students exposure to the skills they're going to need to participate in solving world problems."

> **"It's not just research to solve world problems, but it's also research to give the students exposure to the skills they're going to need to participate in solving world problems."**
> *—Frank Collins, the George and Winifred Clark Chair in Biological Sciences*

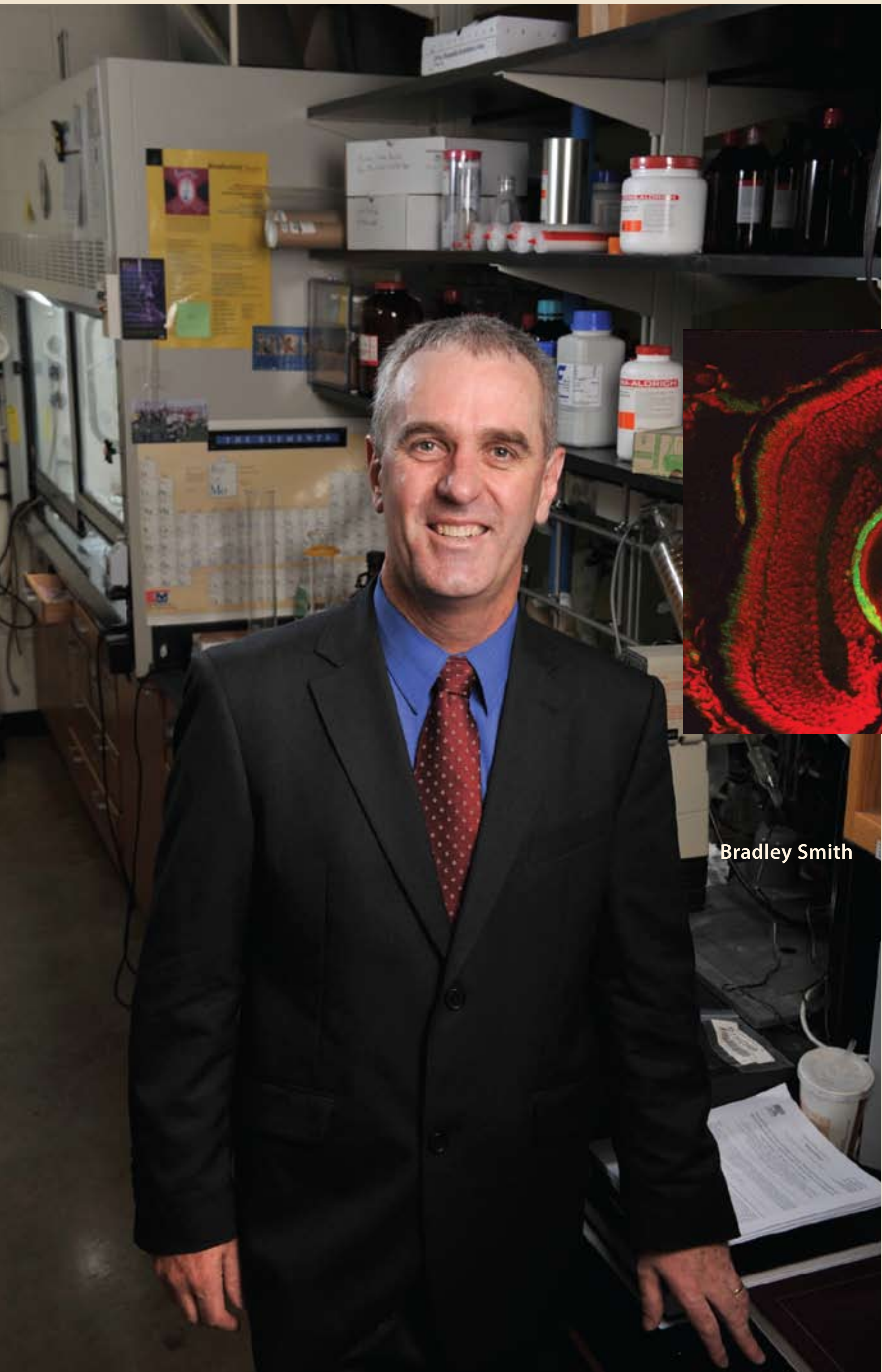
ADVANCED IMAGING

In the second College of Science-based initiative to receive new strategic funding through SAPC, a team of 16 science and engineering researchers will create the Notre Dame Integrated Imaging Facility. This state-of-the-art research resource will expand and consolidate a variety of imaging tools and capabilities, making them more accessible to some 50 separate research groups from not only the College of Science, but also the College of Engineering, the College of Arts and Letters, and the Notre Dame Radiation Laboratory.

Today's most sophisticated microscopes (electron beam and fluorescence) and imaging stations can help researchers in many fields to gain new information and post new questions, says Bradley D. Smith, the Emil T. Hofman Professor of Chemistry and Biochemistry, who led the team proposing this SAPC project. Typically, such equipment is purchased for a particular program or discipline even though it can have multiple uses, Smith says. The cost of a device—ranging from $300,000 to $2 million—argues in favor of buying one for use by the entire campus. At the same time, researchers from around the campus may hesitate to use the device because of lack of familiarity with it.

The imaging facility will unite "discoverers" and "inventors."

The imaging facility will address the latter hurdle by offering technical assistance to all those interested in using particular devices—a group likely to include biologists probing cells and molecules, engineers probing nanoscale particles, and psychologists analyzing images of the brain, according to Smith. He anticipates that the facility will purchase eight new imaging devices, all likely to be used by a variety of specialists from the University and from the surrounding community, including the business community.



Bradley Smith

Smith foresees this fostering "a collaborative culture" where the equipment attracts people who bring different skills and insights to the process of solving interdisciplinary problems. He calls the facility "a forum where people can get to know each other."

As with the SAPC project on global health, this imaging initiative has implications for teaching as well as research, Smith points out. Armed with cutting-edge images and assistance in utilizing the equipment, students will be empowered to create or modify imaging technologies.

The equipment will serve and bring together the group he calls "discoverers"—those probing how the world operates (perhaps at the scale of organisms or nanoparticles)—and the group he calls "inventors"—those focused on solving the technical challenges of the day.


Wolfgang Porod

THE BROADER CONTEXT

Two of the other three initiatives that received support during this year's first round of the SAPC competition are based in the College of Engineering but are inextricably linked to the College of Science through their purposes and their people. Both deal with nanotechnology.

A team of 22 researchers from the fields of electrical engineering, computer science and engineering, chemistry, biochemistry, biological sciences, and chemical and biomolecular engineering won SAPC support for an initiative to develop miniaturized monitoring capabilities for environmental and biomedical uses. The researchers, headed by Paul Bohn, the Arthur J. Schmitt Professor of Chemical and Biomolecular Engineering, envision nanotechnology applications allowing personalized, continuous, and non-intrusive health monitoring at home, for example.

A team of 29 researchers from engineering; science; the Reilly Center for Science, Technology, and Values; and the Gigot Center for Entrepreneurial Studies plans to explore alternatives to standard silicon-based transistor technology. These alternatives include molecular and magnetic Quantum-Dot Cellular Automata, invented at Notre Dame. The work is connected to the cutting-edge research of team leader Wolfgang Porod, the Frank M. Freimann Chair in Electrical and Computer Engineering, and the Midwest Institute for Nanoelectronics Discovery (MIND), a new research consortium led by Notre Dame. MIND also includes Purdue University, the University of Michigan, Pennsylvania State University, the University of Illinois, and the Argonne National Laboratory, among other members.

The fifth winner of SAPC funding in 2008 is a multidisciplinary think-tank proposed by Mark Roche, former dean of the College of Arts and Letters, the Rev. Edmund P. Joyce, C.S.C., Professor of German Language and Literature, and a concurrent professor of philosophy. The new organization will foster collaborations between Notre Dame faculty and visiting scholars focused on the role of religion in modern history and modern knowledge.

The commitment of internal resources from SAPC is in addition to external grants and gifts and various sources of support. The University has been awarded more than $90 million in external research funding during the 2008 academic year. External funding for research at Notre Dame has more than doubled since 2000.


Paul Bohn

Center for Rare and Neglected Diseases Welcomes Director

The University of Notre Dame's new Center for Rare and Neglected Diseases aims at a campus-wide collaboration that will combat diseases from research discovery to treatment delivery. Prof. Kasturi Haldar, the Julius A. Nieuwland Chair in Biochemistry, who came from Northwestern University this year to direct the center, brings novel ways of approaching cell function and pathogen research that have already pointed to unexpected treatment possibilities. She expects the ongoing, open-ended research will involve undergraduate and graduate students, postdoctoral scholars, and faculty.

Left: Kasturi Haldar, director of the Center for Rare and Neglected Diseases, discusses research results with graduate student Sebastian Fernandez-Pol and research technician Jenny Shin.

"That's the plan—to have a comprehensive center of excellence," says Haldar, who expects to work with the College of Science, College of Engineering, the Center for Social Concerns, and the IU School of Medicine. "I think the component parts are in place. We definitely hope to collaborate with the research park that is emerging in South Bend so we can go the full range, from discovery to delivery. That's where we would hope to be able to work with Notre Dame's strong tradition of social outreach. We will base it on existing strengths of the University and build off that. I'm really looking forward to building innovative approaches to studying rare diseases—particularly those involving neurodegeneration—at the new center."

Haldar, who was the Charles E. and Emma H. Morrison Professor of Pathology at Northwestern University, has a Ph.D. in biochemistry from the Massachusetts Institute of Technology and completed a fellowship at Rockefeller University. Her own research has

Kasturi Haldar

focused on understanding cell function, an understanding that is important in itself and can lead to disease treatment. In fact, her identification of how the malaria parasite attacks red blood cells revealed that a common blood pressure drug is able to treat the disease. The drug prevents the malaria parasite from getting into the red blood cell. More recently, she has done research on the role of lipids in ***Salmonella,*** which has led to understanding on how statins—drugs used to lower cholesterol levels—protect against bacterial infections. It has also revealed new pathways that control the proper function of cellular components, called lysosomes, that are defective in storage and neurodegenerative diseases such as Niemann Pick disease.

A focus on interaction at the molecular interface between host and pathogen cells helps identify new functions in the host cell as well as provide possible targets for disease prevention. Traditional approaches to fighting infection often focus on targeting just the pathogen, with the result that pathogens evolve resistance to the treatment. Treatments of the host cell that prevent the pathogen's attack on the host cell can slow down that evolution. "It's really a way of understanding pathogens in host cells and not (just) trying to identify targets for (antimicrobial) prophylaxis, although that's not ruled out," she says. "By understanding that much, it helps us better understand that part of the cell, the pathways and mechanisms of the cell. We try to design our questions so our answers will provide insight into therapeutics for both infectious and inherited diseases. We let the discovery process take center stage. From what we discover, we try to design strategies."

The research takes advantage of modern computer-related tools, especially imaging, genomics, and proteomics, that

have become significantly more sophisticated. "Imaging definitely has advanced enormously over the last few years so that you can take an image within the cell at a resolution we couldn't years ago," Haldar says, adding that images of dynamic processes in live cells allow investigators to follow disease progression in a noninvasive way in whole animals. "You can watch the animal recover by monitoring the animal under the microscope."

Genomics and proteomics have advanced from mapping—identifying the address of an individual gene—to functional genomics, considering the context of neighboring and other genes and proteins. "We can look at a diseased cell and understand at a very broad level all the other genes and proteins that have changed in the cell," Haldar says. "It really gives you a comprehensive picture of the changes. There will be a big focus in trying to develop disease-specific predictive markers. The basic research identifies targets for therapies, putative drugs, etc."

At the clinical level, that means one can identify high risks based on genetic disorders and prescribe therapies. "If you carry certain types of a mutation, you may not respond to certain drugs," she says. "Individuals can make lifestyle choices," such as avoiding fats if one has a genetic disposition to atherosclerosis. It really has very far-reaching implications if you can combine all the tools that have come out of sequencing the genome and identifying proteomes. You need to know the genetics/proteomics of pretty much everything you're working with." This means that you can identify the "critical molecular context" in which a gene defect leads to severe disease and develop diagnostics and treatments that will benefit a person with a mild illness, as well as those who suffer the most.

below: **Michael Barbachyn** and **Steven Brickner** were the lead inventors of the prescription drug Zyvox®, which is the first medicine in a new class of antibiotics that help to treat life-threatening infections caused by highly resistant, hospital-borne bacteria and pneumonia.

Notre Dame Hosts Novel Antibiotics Conference

TWENTY-ONE LEADING RESEARCHERS from universities and pharmaceuticals around the world presented at a conference titled "Novel Antibiotics, Old and New Targets," June 28–29 in the Jordan Hall of Science. The conference assembled leaders from Pfizer, Merck, AstraZeneca, Wyeth-Ayerst, the University of Amsterdam, the University of Gent, the University of Ljubljana, Northwestern University, and numerous other institutions and pharmaceutical corporations that share an interest in developing antibacterial agents.

Presenters shared their work on developments involving highly resistant bacteria, known as "superbugs," for which there are few, if any, treatments. Currently, few pharmaceutical companies are involved in the development of drugs for these bacteria because treatments for other diseases are more profitable. "It's becoming more critical," said presenter Michael Barbachyn, a co-inventor of Zyvox®, from AstraZeneca. "There used to be dozens of companies in this area. Through the '70s and '80s and into the early '90s, there was such a massive presence in the pharmaceutical area. The academic role is going to grow going forward."

Steve Brickner, the leading co-inventor of Zyvox®, who is currently with Pfizer, Inc., also spoke at the conference. Zyvox® was introduced in 2000 in U.S. clinics to treat infections from methicillin-resistant *Staphylococcus aureus* (MRSA), a superbug that still kills about 20,000 people a year in the United States alone. The drug, available in both intravenous and oral forms, will earn $1 billion this year. "What drives all of us is to try to meet some medical need," Barbachyn said.

Another notable presenter was Karen Bush, from Johnson & Johnson, who is spearheading the introduction of Ceftobiprole in the United States. Ceftobiprole, a broad-spectrum antibiotic that also can treat MRSA, was approved this year for treatment of complicated skin infections. Patricia Bradford of Wyeth-Ayerst talked about mechanisms of action and mechanisms of resistance to tigecycline, launched in 2005 under the brand name Tygacil®. "We're always looking for new ideas of new drug targets," Bradford said. "It's good for us to keep a hand on the pulse of what's going on in academia and learn some new science."

Faculty members in the departments of chemistry and biochemistry and biological sciences chaired the sessions. The conference was led by Professor of Chemistry and Biochemistry Shahriar Mobashery, the Navari Family Chair in Life Sciences, who investigates mechanisms of antibiotic resistance in MRSA, among other bacteria, and studies strategies in the development of new classes of antibiotics. He said that the importance of this event is underscored by the difficulties that clinicians are having in dealing with highly resistant bacteria. Some of these infective agents can only be treated with a single available antibiotic or cannot be treated with anything that is available.

above: **Patricia Bradford** and **Karen Bush**

Andrew Loza, a junior chemical engineering major who attended the conference, said the talks gave a new dimension to his studies. "The conference let me see the end purpose of what we're learning in class," he said.

Meetings like the novel antibiotics conference are held every two years, moving between Europe and the United States. The next conference is expected to be in either Warwick, United Kingdom, or Gent, Belgium.

Space Shuttle *Endeavour* Carries Notre Dame Experiments

SOMETIME NEXT SPRING, Vice President and Associate Provost Dennis Jacobs, professor of chemistry and biochemistry, will get the results from a yearlong experiment on the international space station designed to test the ability of several materials to withstand the harsh environment of low-earth orbit. The real-world experiment adds an extraterrestrial dimension to Jacobs' decade of work on such materials-related issues in controlled laboratory experiments at Notre Dame.

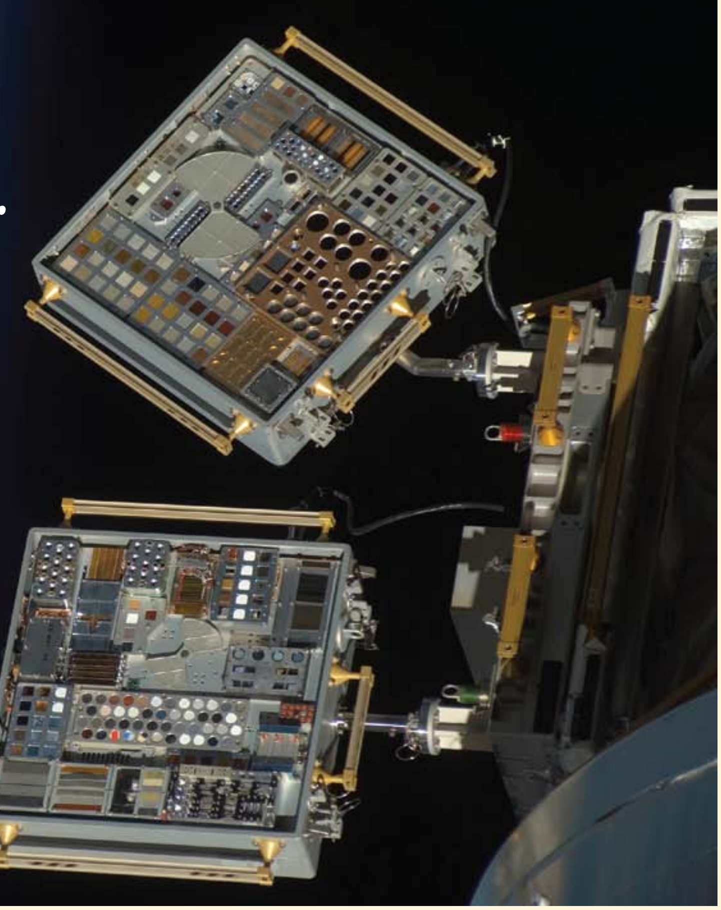


Photo: NASA

The MISSE-6 experiment, equivalent to the size of two large suitcases, is mounted outside the International Space Station for the next year.

Jacobs, along with researchers at other universities and national laboratories, sent more than 1,000 samples attached to the *Endeavour* shuttle when it launched in March 2008. One hundred forty of the samples are from Notre Dame. The project is called the Materials International Space Station Experiment (MISSE-6). Data loggers will keep accurate track of the materials' film thickness every 20 minutes, but the information will not be available until the experiment is complete.

Far different from the emptiness of deep space, the region about 250 miles above Earth contains oxygen atoms, oxygen ions, electrons, ultraviolet light, and other components that can degrade the carbon-based polymers proposed as candidate materials for new lightweight satellites. The corrosive effects are compounded by extreme collision speeds—the space station, for example, travels at 5 miles per second.

Prof. Jacobs and his students will learn what happens to the materials after exposure to the elements of space.

"We have been simulating the environment in space under conditions that are tightly controlled," Jacobs says. "We are trying to gain greater knowledge about the kinds of materials that could survive in low-earth orbit." Corrosion of materials can threaten a mission, as evidenced by the degrading of the Hubble Telescope's thermal control blankets. Ideally, spacecraft materials would be self-healing, able to restore quickly, say, a protective coating that has been damaged by the hostile environment.

Jacobs' team works primarily with oxygen ions. Laboratory simulations in a large vacuum chamber at Notre Dame expose various materials to the energetic oxygen ions encountered in low-earth orbit space flight. To simulate the high collision speeds, researchers accelerate oxygen ions to 5 miles per second before targeting them at a stationary test material. MISSE-6 includes tests on materials such as graphite, diamond, polyethylene, Kapton®, Teflon®, and Polyhedral Oligomeric Silsesquioxane (POSS); the latter has shown the greatest resistance to corrosion in terrestrial experiments. Whereas some samples will be exposed to the unaltered low-earth orbit environment, other samples will be intentionally protected during the entire MISSE-6 mission from one or more of the corrosive components, such as light, oxygen ions, electrons, or oxygen atoms.

Tochko Tzvetkov, the lab manager for Jacobs' research group, and Stepan Starchenko, a 2006 aerospace engineering alumnus, helped to design the experiments. The project, funded by the Air Force Office of Scientific Research, stemmed from a larger collaboration with scientists at the University of Chicago, Montana State, Penn State, Yale, Texas Tech, and Northwestern. MISSE-6 will reveal the harsh reality of space, including the synergistic effects resulting from a combination of particle impacts.

"Any time you simulate an environment, you know you're not going to get it exactly right," Jacobs says. "This will give us an opportunity to test whether the theory and ideas we've developed over the years are consistent with what actually happens in space. It's been a fun project that has required great patience. We started designing the MISSE-6 experiment about four years ago, and we won't see the first results until another space shuttle crew retrieves the experiment and brings it back to Earth next year."

Astronomers Discover Three New Planets

Photo: NASA's Exoplanet Exploration Program

Artist's concept of the newly discovered planet MOA-2007-BLG-192Lb orbiting its star.

WHEN DAVID BENNETT came to the University of Notre Dame in 1996, three extrasolar planets had been identified. Now the number is about 300, including three that Bennett was involved in discovering early this year. Two of those are in the same star system, and the other is the smallest one yet identified, at three times the mass of Earth.

Bennett, a research associate professor of physics, expects discoveries will accelerate with the use of the gravitational microlensing approach as more telescope systems come online. Gravitational microlensing allows researchers to find small objects in space that do not emit light, such as planets and weak or dead stars. Light from a background source bends around the object and is magnified, allowing telescopes lined up with the object and the light source to detect the magnification.

Bennett, who started doing theoretical astronomy when he was a graduate student at Stanford University, went to work on the MACHO project—Massive Compact Halo Objects, named to contrast with the Weakly Interacting Massive Particles (WIMPs). Researchers looked for dark matter in the halo of our galaxy, theorizing that dark matter might be distributed spherically even though the stars in our galaxy reside in a disk. The search was also aimed at the nearby Magellanic Clouds.

"When I was in graduate school, searching for planets around other stars was not considered a very serious part of astronomy," Bennett says. "People tended to think it was observationally impossible to make progress in the field. In 2005, we started discovering planets of quite low mass, five to 10 times Earth's mass."

In February of this year, Bennett was part of a large international collaboration that announced the discovery of two exoplanets about the size of Jupiter and Saturn in the system of a star with about half the mass of the Sun. This collaboration consisted of the Microlensing Follow-Up Network (MicroFUN), the Optical Gravitational Lensing Experiment (OGLE), and the Microlensing Observations in Astrophysics (MOA) collaboration, along with some members of the Probing Lensing Anomalies NETwork (PLANET).

In June, Bennett led an international research team that announced the discovery of an extrasolar planet with just three times Earth's mass. He said, "Our discovery indicates that even the lowest-mass stars can host planets."

Researchers have concluded that, at most, such objects can account for only a small fraction of the dark matter in the Universe. Microlensing is used more in the search for exoplanets in our galaxy and is aimed at the center of the disc rather than the halo. Most of the observations come from the Southern Hemisphere, with collaborators in South Africa, Australia, New Zealand, Chile, Brazil, and Europe.

"It's mostly computer analysis work we do here," says Bennett, who led the computer modeling efforts for both discoveries. More people and more equipment in the field should increase the rate of discoveries, he says.

Chemistry Alumna Discusses Discovery of Januvia™

Ann Weber ND '82, led a team of chemists and other scientists at Merck in the discovery of Januvia™, a new treatment for Type 2 diabetes.

Ann Weber ND '82, remembered taking analytical chemistry in the Nieuwland Science Hall classroom in the days before carpet, computers, and padded chairs. She started the semester in the back row and wound up in the front.

Last semester, she was back down front, giving a lecture on the discovery of Januvia™ (generic: sitagliptin), a new treatment for Type 2 diabetes. Weber, who later graduated as valedictorian at Notre Dame and earned a Ph.D. in Organic Chemistry from Harvard University, is now the executive director of medicinal chemistry at Merck Research Laboratories.

"She was always a very attentive person," said Marvin Miller, the George and Winifred Clark Chair in Chemistry, who taught Weber organic chemistry. "She would follow everything and was usually one step ahead of us."

Her address, which Miller aptly described as "a mini course in medicinal chemistry," was part of the Organic Seminar Lecture Series sponsored by the Department of Chemistry and Biochemistry.

Weber co-led a team of chemists and other scientists at Merck who synthesized a drug that inhibits the action of the enzyme dipeptidyl peptidase IV (DPP-4). This drug improves glucose tolerance by increasing the circulation of incretin hormones that induce biosynthesis and secretion of insulin and prevent the release of glucagon, which works against insulin.

"Her background in chemistry really prepared her well," Miller said. "She's not only a great chemist but also a fantastic leader."

The FDA approved the drug in October 2006 and approved Janumet™, a combination of sitagliptin and metformin, another commonly used antidiabetic agent, in April 2007. The drug is especially important because of a worldwide increase in cases of Type 2 diabetes, also known as adult-onset diabetes, that is often linked to obesity. Experts expect 366 million cases of diabetes by 2030, up from 171 million in 2000. More than 90 percent of the cases are Type 2.

High glucose levels result from insufficient use of the sugar by the muscles, defective insulin production in the pancreas, and overproduction of glucose in the liver. Other treatments attack the problem by stimulating the pancreas to make more insulin or by helping the muscles take up the glucose, but they have side effects and limited effectiveness. "None of these work long-term," Weber said. Sitagliptin also avoids such side effects as weight gain and hypoglycemia that some other diabetes drugs can bring.

The process of developing the drug started with the hypothesis that inhibiting DPP-4 would reduce glucose levels and proceeded along parallel lines as researchers tried various chemicals. Early tests with an inhibitor of DPP-4 showed that it blocked other enzymes related to DPP-4, resulting in toxicity. Merck wanted to develop a drug that selectively inhibited DPP-4 without blocking the related enzymes, to avoid this toxicity. The drug also needed to be available in pill form for patients to take orally, once or twice a day. (Januvia™ requires only one dose a day.)

Researchers found ways to make a more selective drug, affecting DPP-4 and not the other family members, but early versions were not absorbed in the body and did not work when given orally. One series was dropped when they discovered that it also blocked an important ion channel.

"We tried to run as many assays as we could in parallel, in order to optimize many different properties of our molecules as quickly as possible," Weber said. The researchers, using structure-activity relationship (SAR) studies, were able to develop a series of inhibitors that were potent, selective, and worked when administered orally. Optimization of this series led to the discovery of sitagliptin.

Studies submitted to the FDA showed significant glucose lowering effects of two different doses of sitagliptin compared to a placebo. Preclinical studies showing improvement in islet morphology suggest that the treatment might slow the process of the disease.

Total sales for Januvia™ and Janumet™ were $ 1.2 billion for the first three quarters of 2008.

In addition to her leadership role in this project, Weber is co-inventor of 23 U.S. patents (with 14 pending) and is author or coauthor of more than 55 publications. Her research team last year won the Prix Galien USA award for their work on Januvia™, and she received the Merck Director's Award and the Thomas Alva Edison Patent Award. In 2006, she was named a Merck "Most Amazing Woman."

Unfortunately, rules prevented naming the newly invented drug, in the gliptin class, after the team leader. "It couldn't be webergliptin because you can't have a 'w' in a generic name," she explained. "There are lots of rules." The one name submitted was rejected, and sitagliptin was suggested instead. "We didn't like it at first, but it kind of grows on you," Weber said.

The selection of Januvia™ for the brand name was the result of far more intensive market research. Fittingly, she said, the marketing team leader was Phyllis Stone ND '80, a former cheerleader at Notre Dame.

Meet the Dean

Dean Gregory P. Crawford became dean of the College of Science on July 1, 2008.

Q. What led you to become dean of the College of Science at Notre Dame?

A. Before coming to Notre Dame, I was dean of engineering and professor of physics and civil engineering at Brown University. I was drawn to Notre Dame because of its Catholic character and mission, rich tradition, deep commitment to undergraduate education, extraordinary faculty and students and the accomplishments of alumni. Jordan Hall. Wow, what an impressive place to learn science. The Jordan facility and infrastructure are enjoyed and utilized by so many in the sciences. It is our showcase, and it will be the place where students receive the best science education in the world. Jordan Hall deeply influenced my decision to come to Notre Dame.

Q. We've heard that you started two companies and hold 16 U.S. patents. What advice would you give a young student with exceptional entrepreneurial potential?

A. Go for it. There is nothing more satisfying then to see your science make a difference in the world. Keep your eyes open for Innovation Park at Notre Dame in the fall of 2009. It will be a place of great opportunity for students and faculty to pursue entrepreneurial ideas.

Q. How are you building collaborations at Notre Dame?

A. We're creating opportunities for faculty to connect with leaders in their fields, researchers and innovators from medical centers, our advisory council, and with faculty across scholarly disciplines. Through special events, we've encouraged our graduate students to meet their peers and faculty members in other departments to develop interdisciplinary partnerships.

Q. What's your secret for starting collaborations?

A. Engage people in discussions by asking, "What problems are out there that need to be solved?" rather than seeing if you have a research area overlap. The synergy across disciplines will then develop, and the passion to work collaboratively toward a common goal will naturally develop.

Q. What are some of the changes we can expect to see across the college?

A. We're excited about building our interdisciplinary research programs, crossing scholarly boundaries and bringing our science to create new opportunities and solve challenging problems. From global health to rare disease to complex systems and nuclear astrophysics, our faculty do it all. We will build upon our disciplinary strengths and grow our interdisciplinary interactions. Our "think big" attitude and desire to be a force for good in the world will help us lead the way in solving the world's most challenging problems.

Because of this, there will be more opportunities for undergraduates to engage in research and apply the knowledge they're acquiring in the classroom.

Across the College of Science, special professional faculty teach, conduct research, coordinate laboratories, guide students to professional schools, and share the University's research knowledge and expertise with the community.

Department of Biological Sciences


Michelle Whaley


Kristin Lewis


T. Mark Olsen

Special professional faculty in the Department of Biological Sciences work with faculty, graduate, and undergraduate students, and sometimes even younger students and local residents, as they extend the University's research and education into the surrounding community. "All of them are invaluable to our teaching of laboratories in Jordan Hall," says department Chair Gary Lamberti. They are especially interested in developing programs that make vivid connections between research and real life.

Michelle Whaley was receiving her Ph.D. in biology at Notre Dame in 1993 when the University received a Howard Hughes Medical Institution grant for research-based laboratory courses in genetics and cell biology. Whaley stayed to develop the programs and has continued to expand research, recently reaching into the local community with students to work on the problem of pet overpopulation.

Students in the semester-long guided genetics research program on a retinal degeneration gene produce three drafts of a 25-page paper on the accumulated data that repeats a known experiment. The cell biology course is an independent study where teams of five or six, working with a volunteer faculty mentor, select, design, and carry out novel research. They spend 15 to 20 hours a week and present their work three times during the semester. "It's a big time commitment," Whaley says. "I think that's where Notre Dame students really shine."

The cell biology course is an independent study where teams of five or six, working with a volunteer faculty mentor, select, design, and carry out novel research.

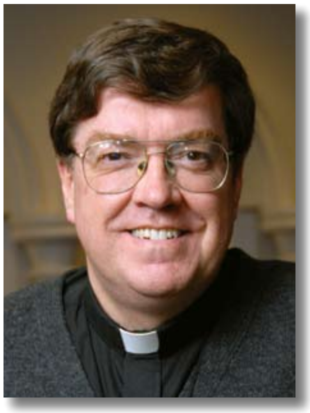
Whaley teaches an introduction to undergraduate research and directs the NSF-funded Research Experience for Undergraduates. She also advises the Biology Club, where students get involved in K–8 science education such as judging science fairs, and volunteer at the Humane Society. Whaley and Kay Stewart, associate professional specialist and associate director of the Freimann Life Sciences Center, have developed a service-learning course where students learn about animal behavior, disease transmission, and reproductive biology. The students have recruited veterinarians for a spay-neuter program for pets of local low-income residents, and the class will do quantitative social science research to assess such issues as why clients use the program.

For 10 years, **Kristin Lewis** has worked to make a large sophomore introductory biology lab course more research-based than it was when she was a science preprofessional undergraduate and a graduate teaching assistant (earning her master's degree in 1997 with research on the zebra mussel). She designed the year-long course, which can have up to 350 students, and trains the graduate student instructors and undergraduate teaching assistants.

"We've tried to select course projects that have a genuine research component and a connection to the real world."

Lewis also has a lot of student contact. She says, "I really enjoy the direct teaching. The focus of my work has shifted to developing projects that are taught in the lab. We've tried to select course projects that have a genuine research component and a connection to the real world." In the fall, students study the effects of mutation in a gene linked to hereditary colon cancer, and in the spring, they design their own experiments to examine the response of plants to elevated carbon dioxide levels. Lewis' graduate work convinced her that the course could be more challenging. "We're really trying to give students what I call a structured research experience," she says. Her laboratory plans and testing schemes, which are part of the general biology course (BIOS 20201), were identified as one of the top examples of best practices in a national study conducted across the nation on behalf of the College Board.

T. Mark Olsen, who earned his master of science in ecology in 1989 and his Ph.D. in physiology and biochemistry in 1994, both at Notre Dame, teaches an introductory laboratory course for honors students and biology majors, overseeing six graduate TAs and 20 to 25 undergraduate TAs who work with some 200 students. He designs, directs, and participates in laboratory setup, advises students on PowerPoint presentations and designs, and conducts scientific writing workshops. Olsen designs, revises, and publishes a 200-page laboratory manual each year. He also teaches a summer introductory ecology and environmental science course for non-majors and codirects a two-week summer program with gifted high school juniors in field and laboratory-based research. ■



Rev. James Foster, C.S.C., M.D.

Kathleen Kolberg

Jennifer Nemecek

Center for Advising in the Health Sciences Advising

Three advisors in the Center for Health Sciences Advising shepherd more than 350 applications to medical and other health-related schools each year, up from 140 applications just four years ago. The process, which starts with a personal interview in the junior year, includes meeting with students, collecting letters of reference, and writing cover letter recommendations that summarize the students' academic and personal achievements.

Rev. James Foster, C.S.C., M.D., assistant dean and director of the center, is a 1977 Notre Dame biology alumnus who earned his medical degree at the University of Illinois Medical School before joining the Congregation in 1989. Father Foster teaches Introduction to Clinical Ethics and traditionally sings at Commencement.

In addition to handling applications, Foster serves as an academic advisor to about 325 science preprofessional majors.

Assistant Dean of Undergraduate Studies **Kathleen Kolberg**, who earned a Ph.D. in biological sciences from Notre Dame, teaches Embryology in the fall and Psychology of Medicine in the spring, in addition to her advising duties. She is a consultant to local Memorial Hospital's neonatal intensive care unit on research and education. Her most recent published research examined the impact of single-family rooms compared to open-style designs in the NICU.

Assistant Dean **Jennifer Nemecek**, the preprofessional advisor for the College of Arts and Letters, has offices in Jordan Hall and O'Shaughnessy Hall. About one-third of applicants to health profession schools, both nationally and at Notre Dame, are arts and letters majors. The Notre Dame program requires higher-level science and math courses than most colleges for preprofessional majors, Nemecek says.

The three advisors are all members of the National Association of Advisers to the Health Professions. ■

Department of Chemistry and Biochemistry

Notre Dame's only reliable mass spectrometer was three years old when **Bill Boggess**, who had just earned a Ph.D. in chemistry from the University of Tennessee at Knoxville came in 1994 to manage the Mass Spectrometry Facility. That molecule-weighing instrument is still working, although the NSF recently granted money to replace it. The facility is rapidly adding more modern equipment.

"We've moved well beyond organic chemistry," Boggess says. "We've become interdisciplinary." He works mostly with graduate students, but also with undergraduates and occasionally with high school students, confirming the compounds they have created and providing data on cutting-edge topics such as proteomics and metabalomics. The facility added one new instrument in May 2008, has NSF money for another, and is seeking funding from the NIH and Notre Dame for two more.

Boggess, assistant chair in the Department of Chemistry and Biochemistry, also oversees the infrastructure, including maintenance of critical equipment such as exhaust fans to maintain indoor air quality in laboratory buildings and renovations of labs and common areas. He also volunteers with an after-school science club at Clay Intermediate Center, helps judge science fairs, and takes chemistry-related calls from the public.

For 10 years, **Sarah West** has coordinated portions of the first-year chemistry course that has some 1,000 students. West, who came to Notre Dame when she graduated from Augustana College in 1998 with a degree in biology and chemistry, spends about half her time on behind-the-scene work and about half interacting with students in labs, recitations, or one-on-one.

Bill Boggess

While tenured professors teach the class, West sets up classroom demonstrations, posts homework assignments and other class management information online, and supports Jim Johnson, associate professional specialist, who sets up 10 to 15 lab sections for the students. She also runs some recitations, groups of 25 students who meet one day a week, and keeps office hours where students can talk to her. For many, she says, the course is the most difficult challenge they have faced so far. "I like helping the students, West says. I love working with the freshmen."

DeeAnne Goodenough-Lashua, who has been with the Department of Chemistry for seven years, earned a Ph.D. in medicinal

Sarah West

DeeAnne Goodenough-Lashua

chemistry with a biochemistry focus from the University of Michigan. She teaches lab courses with topics that relate to classroom lectures as much as possible. "Mostly, I'm involved in teaching undergraduate chemistry labs," she says. "I teach the biochemistry labs at both the undergraduate level and the graduate level. I also teach various organic chemistry lab courses. We develop the experiments, and we're involved in the day-to-day running of the labs." Goodenough-Lashua typically teaches about 30 undergraduate students in the fall and 10 graduate students in the spring. The course for chemistry majors can have up to 70 students, while courses for preprofessional majors can have as many as 500 students. The laboratory environment gives plenty of opportunities to interact with students. "We really get to know them," she says. "We get that one-on-one contact with them." ■

Department of Mathematics

Arthur Lim's role in the Department of Mathematics isn't about doing both teaching and research—it's about the union of the activities as a way of solving problems. Lim, who earned a Ph.D. in mathematics at the University of Utah in 2001, came to Notre Dame in 2006. He supports undergraduate education by teaching three classes per semester and providing faculty with teaching resources. He shares responsibility in organizing a teaching seminar every year on pedagogy, quiz writing, and people skills.

Lim's research field is representation theory of lie algebra and plane symmetry groups. He has been published in the *Journal of Mathematical Analysis and Applications* and in *Linear Algebra and Its Applications*. He expects to do more research in the mathematics of symmetric patterns, such as those on tile floors or wallpapered walls.

"My passion for teaching and affinity for research in mathematics fuel my pursuit of an academic career in which I wish to create a dynamic learning environment for young minds and to allow my own mind to bask in an equally stimulating environment," he says. "I'm driven by my passion toward the subject." ■

Arthur Lim

Physics

Special professional faculty members in the Department of Physics keep the computers and other equipment running on campus. They also spread the teaching and research efforts of the University into a wide range of other educational environments, providing innovative opportunities especially for K–12 teachers in the local community.

For nearly 40 years, through vast changes in computers and electronics, **James Kaiser** has taken care of accelerators and other equipment in the Nuclear Structure Laboratory, a part of the Institute for Structure and Nuclear Astrophysics. His duties are easily defined, colleagues say: "If it has a wire in it, it's Jim's," covering everything from power wiring to data acquisition electronics. Kaiser, who earned a master of arts in teaching from Notre Dame in 1967, returned to campus after two years of teaching high school science. Ever since then, he has provided support for faculty, postdocs, and graduate students in their research, from computer administration to designing and building equipment. He earned a master of science in electrical engineering at Notre Dame in 1978.

James Kaiser

Tom Loughran and **Patrick Mooney** work together in the Notre Dame ***e***xtended Research Community (ND***e***RC), funded by National Science Foundation Graduate Teaching Fellows in K–12 Education (GK–12). Loughran wrote the grant that launched the project and is managing coprincipal investigator. Mooney is project coordinator. The outreach to the community is the fruit of almost a decade of collaboration among members of the Notre Dame QuarkNet center.

Loughran earned a bachelor of science in chemistry in 1980, a master of philosophy in 1983 and a Ph.D. in philosophy in 1986, all at Notre Dame. He is also education program leader for Interactions in Understanding the Universe (I2U2), a collaboration of scientists, computer scientists, and educators that extends university research to younger students through virtual laboratories on the Internet. Part of the I2U2 work involves teaching research at St. Joseph's High School. After two one-year NSF grants for the program, I2U2 recently received a three-year grant. Loughran is involved in proposal development and numerous education and public outreach programs, including the steering committee for a national group working on supercomputing educational programs.

Mooney earned a bachelor of science in physics in 1978 and a Ph.D. in physics in 1986, both at Notre Dame. As a graduate student working with Randal Ruchti, he participated in Experiment 515 at Fermi National Accelerator Laboratory and wrote his dissertation on hadro-production of charmed mesons. As a postdoctoral student at Michigan State University, he participated in the D-Zero experiment at Fermilab and was a coauthor on the discovery of the top quark. He continued D-Zero research while an assistant professor of physics at Universidad de Los Andes in Bogota, Colombia. Mooney started teaching high school physics at Trinity School at Greenlawn in 1996 and joined Notre Dame's Department of Physics part-time in 1998, when he helped Ruchti and others write the proposal for QuarkNet. He became full-time in 2007.

"It was natural for me to work with other K–12 teachers in the area. It was also quite natural to work with University personnel," Mooney says, adding that the union of research and outreach is central. "Right from the beginning, the group emphasized both the research aspect and the community aspect of our work." ■

Tom Loughran

Patrick Mooney

Lauren Fowlkes

science-business major

Lauren Fowlkes knows how to reach a goal. The sophomore from Missouri is playing on both the University of Notre Dame soccer team and the U.S. Under-20 Women's National Team, with the World Cup coming up later this semester. Fowlkes is also pursuing a science-business major, preparing for life after soccer—whenever that comes.

"I've always had this love for the game," says Fowlkes, who also was on the U.S. Under-17 Women's National Team and hopes to play professional soccer when she graduates. "I started playing when I was 4 years old. I've been on so many trips and had so many great experiences and met so many great girls. I feel like it's become part of who I am. I'm playing for my country, and that's always been one of my goals."

Participating on the national team sometimes takes her out of classes, but she is managing a schedule that included organic chemistry last semester and biology this semester. Last year, Fowlkes, who is usually a center defender and sometimes plays midfield, started all 26 games and logged 2,324 minutes, the team high. The sport makes her a better student, she says.

"I think it teaches you a lot of life lessons," Fowlkes says. "It teaches you to focus on a goal and work hard. I've always been very interested in science. I'm not 100 percent sure what I'm going to do. With the science-business major, I have such a good array of options. I'd like to do something with people—helping people in the workplace—after I'm finished playing soccer. I can go back to nursing school or physical therapy school or I can do health care administration. I feel it's something I'm working hard at. I can figure out what I want to do with my major and end up being happy."

GO IRISH!

Record Number of Mathematics Seniors Receive Fellowships

Counter clockwise from left: **Ben Fehrman, Adam Boocher, Andrew Fanoe, Andrew Karl, Matt Hudelson, Jacob Hughes and Matt Gunden.**

This past spring, a record eight seniors in the Department of Mathematics received fellowships to attend prestigious graduate schools. **Andrew Fanoe** received a fellowship from Columbia University, where he plans to complete a Ph.D. in mathematics. **Andrew Karl**'s fellowship from Arizona State allows him to pursue a Ph.D. in statistics. **Phil Hudelson** received a fellowship from Penn State, where he plans to complete a Ph.D. in mathematics. **Zach Lamberty** will be a fellow at Cornell University, where he plans to obtain a Ph.D. in physics.

Jacob Hughes will be attending the University of California at San Diego, where he plans to pursue a Ph.D. in Mathematics. **Ben Fehrman**, a Goldwater Scholar, plans to attend the University of Chicago, where he will complete a Ph.D. in mathematics. **Matt Gunden** is pursuing a Ph.D. in economics at Northwestern University. Recent alumnus **Zach Madden** ('07) is a current Ph.D. student in mathematics at the University of Chicago.

Adam Boocher received the National Science Foundation Graduate Research Fellowship Award. He was one of only 23 mathematics majors in the country to be so honored. Boocher is studying at the University of California Berkeley with a focus on algebra or number theory. Four other senior honors mathematics majors, Jacob Hughes, Ben Fehrman, Matt Gunden, and alumnus Zach Madden received honorable mentions from the NSF Graduate Research Fellowship Program. Two other College of Science alumni from the class of 2007—**Julian Bigi**, a biochemistry major, and **Timothy Chlon**, a biology major—also received NSF Graduate Research Fellowship Awards.

The NSF Graduate Research Fellowship Program provides students with three years of funding—up to $121,500—for research-focused master's and doctoral degrees in science, technology, engineering, and mathematics. The purpose of the NSF Graduate Research Fellowship Program is to ensure the vitality of the human resource base of science and engineering in the United States and to reinforce its diversity.

In addition to being in the honors program, all of these students were members of SUMR, the Seminar for Undergraduate Mathematical Research, a program for the most-gifted mathematics students at the University of Notre Dame. Thirty-two SUMR students have received national fellowships since 1990, and nearly all SUMR graduates have completed graduate work at some of the nation's leading universities.

Goldwater Scholarships

Senior Andrew Manion and junior Eric Riedl have each been awarded Barry M. Goldwater scholarships for the 2008–09 academic year. Both Manion and Riedl are double majors in mathematics and music who plan to pursue doctorates in mathematics and careers in teaching and research after graduating from Notre Dame. Both students are participants in SUMR.

The Barry M. Goldwater Scholarship and Excellence in Education Program was established by Congress in 1986 to honor the senator who served his country for 56 years as a soldier and statesman.

Ruchti Named Associate Vice President

In July, **Randal Ruchti**, longtime professor of physics, became an associate vice president in the Office of the Vice President for Research. Ruchti, who will continue to conduct research and teach physics, says he expects to help facilitate campus-wide cross-departmental collaboration. Ruchti will focus on developing research across the entire University. "It's not specific only to science or engineering," he says.

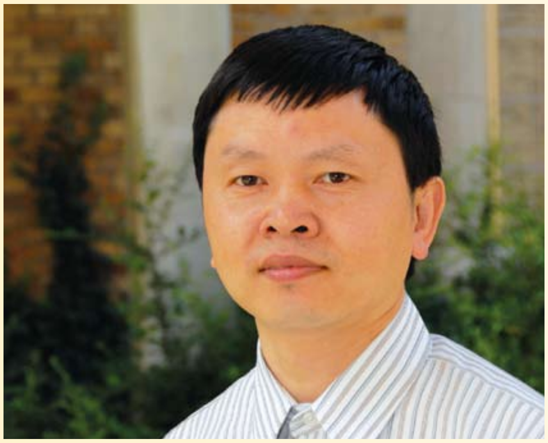

Randal Ruchti

Ruchti recently returned from a three-year assignment at the National Science Foundation (NSF) where he was a program director, bridging the government/university divide. His work involved collaborating with other NSF departments and securing funding. He also served on the Strategic Academic Planning Committee (SAPC) before taking this position.

Ruchti, who earned a Ph.D. in physics from Michigan State University, came to Notre Dame in 1977. His own research in particle physics has involved developing new detectors for rapid and precise measurements of particle trajectories, momenta, and energy. He has been a member of the Department of Energy's (DOE) High Energy Physics Advisory Panel, a group of particle physics researchers from universities and laboratories across the nation who advise NSF and DOE on developments in the field of high energy physics. He started the QuarkNet national program in the late 1990s in order to reach secondary school teachers and students when it became clear that data from an important CERN experiment in Geneva, Switzerland, would not be available for roughly a decade until the facility and its major experiments were fully constructed and brought into operation. "You've got to reach back," Ruchti says, explaining that engaging younger students in science is important for preparing future graduate students. "It's going to be more and more like that across the sciences in the future. The system doesn't function unless you reach back to help enrich and strengthen the professional development for teachers and provide immersive research opportunities for both teachers and secondary school students."

While specialization within departments is important, Ruchti sees a move away from the "stovepipe" arrangement of parallel, disconnected departments. Hurricane Katrina, for example, demonstrated the interdependence of such diverse fields as meteorology, geography, civil engineering, social services, networked computing, and psychology. Likewise, the development of Innovation Park will involve law, business, and social science, as well as science and engineering. The big questions that academics deal with also call for a wide range of expertise, and he wants to build bridges not only among the sciences, but also with the humanities. "I think the way we're headed has suggested to many of us that those dominion boundaries should not be rigid," Ruchti says, adding that Notre Dame's rich historical and cultural tradition makes the campus fertile ground for such cooperation: "This is a wonderful place to mix it."

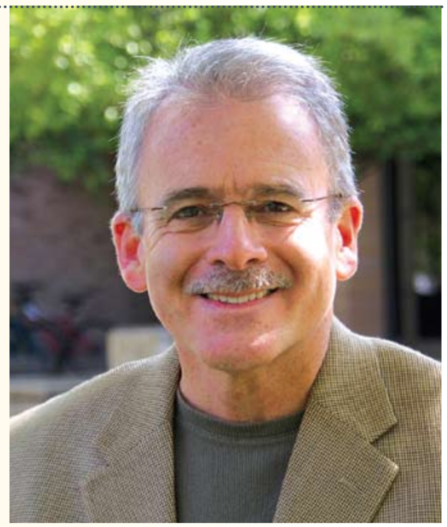
Hu Becomes Chair of Mathematics



Bei Hu

The College of Science is pleased to announce the appointment of **Bei Hu** as chair of the Department of Mathematics. Hu, who came to the University 18 years ago, served as associate chair of the Department of Mathematics this past year. He has served on several committees, including the committee of appointments and promotions for the department. In 2006 and in 2000, he received Kaneb teaching awards for his outstanding teaching of undergraduates. He has received several grants from the National Science Foundation and co-organized several conference sessions, including the American Mathematical Society Special Session in Mathematical Biology (2006). Hu earned a Ph.D. and a master's of science in mathematics from the University of Minnesota as well as bachelor's and master's degrees from East China Normal University.

Lamberti Appointed Chair of Biological Sciences



Gary Lamberti

The college is also pleased to announce **Gary Lamberti** as chair of the Department of Biological Sciences. Lamberti served as assistant chair and director of graduate studies for the department since 2001, a position in which he oversaw the recruitment and training of approximately 140 graduate students. Lamberti is the recipient of the Shilts-Leonard Teaching Award from the College of Science (2003) and the James A. Burns, C.S.C., Award from the Graduate School (2004). Before coming to the University of Notre Dame in 1989, he conducted research at Oregon State University in the Department of Fisheries & Wildlife, preceded by a postdoctoral position at the University of California at Berkeley. He is an editor of the textbook *Methods in Stream Ecology*, which was recently published in its second edition. Lamberti earned a Ph.D. in entomological sciences at the University of California at Berkeley and a bachelor's degree in entomology at the University of California at Davis. At Notre Dame, he has directed research of nine M.S. students, 15 Ph.D. students, and seven postdoctorates.

Taylor Named Associate Dean

Richard Taylor

Richard Taylor, professor of chemistry and biochemistry, has been appointed to the position of associate dean of the College of Science. In his position, Taylor directs the research and planning efforts of the College of Science, oversees grant management, engages faculty in multidisciplinary research, and assists in forming strong collaborations across the University and with external research partners. He serves as the college's primary liaison with the Office of Research and the Graduate School. Taylor also directs the Science Computing Facility.

Taylor's own research program sets an example for the rest of the college. His research group, which specializes in synthesis, conformational analysis, and polyketide biosynthesis, has contributed to the understanding of chemicals that can be used to fight cancer. The group has completed the synthesis of four epothilones, three myriaporones and the marine polyketides, peloruside A. Conformational analysis of the epothilones, coupled with biological activity data, has improved the understanding of the structural and conformational constraints of binding. Some of its analogues have been patented and licensed to the pharmaceutical industry for further development.

Taylor says the group's study of conformation-activity relationships complements the classic structure-activity relationships to provide detailed pharmacophore models that can help design future drugs used in chemotherapy. The group, using genetically engineered organisms, has also demonstrated the semi-synthetic production of epothilone natural products and analogues, allowing production of the compounds at less cost than total synthesis. In the process, the group has developed new synthetic methodologies. Taylor's group includes one postdoc, nine graduate students, and four undergraduates. Thirty other graduate students, postdocs and visiting researchers have been on his team since he came to Notre Dame in 1995.

Kasturi Haldar,
Julius A. Nieuwland Chair in Biology

Kasturi Haldar, professor of biological sciences, was appointed the Julius A. Nieuwland Chair in Biology. Haldar directs the University's new Center for Rare and Neglected Diseases, a campus-wide collaboration aimed at combating diseases from research discovery to treatment delivery. Her work involves novel ways of approaching cell function and pathogen research that have already pointed to unexpected treatment possibilities.

Haldar was previously the Charles E. and Emma H. Morrison Professor of Pathology at Northwestern University. She holds a Ph.D. in biochemistry from the Massachusetts Institute of Technology.

Kevin Lannon
Assistant Professor of Physics

Kevin Lannon, assistant professor of physics, came from the Ohio State University where he was a postdoctoral researcher. His research, which focuses on elementary particle physics, has been published in the *Physical Review Letters, Physics Review,* and *Nuclear Instruments and Methods*. He has held several collaborative leadership positions in the CDF collaboration, which takes data at the Tevatron accelerator, currently the world's highest energy particle accelerator. Since coming to Notre Dame, he has joined the CMS experiment at the Large Hadron Collider in Geneva, Switzerland, which will become the world's new highest energy particle accelerator when collisions start this spring.

Lannon earned a Ph.D. in physics from the University of Illinois, Urbana-Champaign in 2003.

Undergraduates Use Analytical Chemistry to Assist Haiti Program

Undergraduate researchers in Analytical Chemistry are supporting the Notre Dame Haiti Program with experiments and tests on salt additives used in Haiti to provide iodine and to fight lymphatic filariasis, a parasitic disease also known as elephantiasis. The students are studying how homogeneously the sprayed-on additives are distributed in the salt, how to check the concentrations to be sure the salt contains the proper amounts, and how washing the salt, a common practice in Haiti, affects the additives.

Notre Dame priest and biologist Rev. Thomas G. Streit, C.S.C., who started the project, asked Marya Lieberman, associate professor of chemistry and biochemistry, for help with the analysis. The Haiti project involves adding both iodine and diethylcarbamazine citrate (DEC) to salt for its important health benefits. Lieberman says, "Iodine is important for proper thyroid function and proper brain development." The DEC kills the nematode that causes lymphatic filariasis, which causes gross swelling of body parts because of the body's reaction to the parasitic nematode.

"We're trying to test the salt, to see if it has a sufficient amount of the iodine and DEC," Rangel says. Patrick Brown, a senior majoring in physics and chemistry, says the experience helps him see the importance of chemistry for life. "I'm interested in practical applications of chemistry."

Brennan Bollman, **Alyssa Rangel**, and **Patrick Brown**, along with other students in Analytical Chemistry (Chem 31333) analyze samples of Bon Sel, the treated salt that is marketed in Haiti, to check for dosage and distribution of the additives.

Above: **Adam Boocher** and **Adam Gadzinski**

Brown Receives Teaching Award

Seth Brown, associate professor of chemistry and biochemistry, received the 2008 Shilts/Leonard Teaching Award, the College of Science's top teaching honor. He accepted the award at the College of Science Awards Luncheon on May 16 with a captivating demonstration that made a teaching metaphor of his research in catalysis.

Surprising the audience, Brown vigorously shook two pop cans in succession—an orange can and a green can. In the first, the bit of orange flavored seltzer water, it turns out, catalyzes the release of the carbonation in a way missing in the unflavored water. The orange pop sprayed everywhere as Brown continued his metaphor comparing a teacher to a catalyst who can catalyze a student, accelerating or guiding the student's thought. The impetus comes from the substrate—the student—rather than from the catalyst, and one catalyst can speed up the reaction of many different molecules.

"My research is directed toward catalysis," said Brown, who currently has a team of a postdoc and five undergraduates focusing on homogeneous catalysts. "Our fundamental interest is understanding why and how molecules react the way they do. Mostly, we try to think of new ways that molecules might react. Catalysis can't make impossible things happen. Catalysis can make possible things happen more rapidly."

Catalysis is getting more attention in manufacturing because the methods are often environmentally more benign. Using just a pinch of catalyst rather than larger amounts of reagents decreases both energy chemical waste and energy use. Among other things, catalysis is involved in fuel cells using methanol or hydrogen. Industrial chemists find the research practical because it helps identify more promising subjects for manufacturing applications.

Brown, who is admired by faculty and students alike, came to Notre Dame in 1996. He has been teaching and doing research since he was a sophomore at M.I.T., where he earned his undergraduate degree in 1988. He earned a Ph.D. at the University of Washington in 1994 and was a postdoc for two years with Nobel Prize-winner Bob Grubbs at Caltech. He enjoys the combination of teaching and research.

The analogy of teacher and catalyst breaks down, Brown told his awards luncheon audience, at a critical point: The chemical catalyst returns to its original state, but the human catalyst doesn't. "I, too, have changed—not just the student," he said.

College of Science Awards Luncheon, May 2008

Dean's Award
Adam L. Boocher, Adam J. Gadzinski *(see photos, left)*

Department of Biological Sciences

Outstanding Biological Sciences
Laura A. Campochiaro, Zachary H. Lemmon
Molly J. Harding, Kayleigh A. Trimble
Blake C. Jones, Lisa A. Zickuhr

Paul F. Ware, M.D., Excellence in Undergraduate Research Award
Jennifer M. Enright

Department of Chemistry and Biochemistry

Merck Index Award
Michael C. Burns, Stephen J. D'Auria

Outstanding Biochemist
Reid W. Merryman

Outstanding Biochemistry Research Award
Nathan A. Serazin

Outstanding Chemist
Anita B. Lyons

Outstanding Chemistry Research Award
John B. Randazzo

Dr. Norbert Wiech Award
Ruth F. Sommese

William R. Wischerath Outstanding Chemistry Major Award
Ruth F. Sommese

Department of Mathematics

Robert P. Balles Notre Dame Mathematics Scholar
Adam L. Boocher

The Kolettis Award
Adam L. Boocher

The Senior General Electric Prize for Honors Majors
Adam L. Boocher, Benjamin J. Fehrman

The Senior General Electric Prize for Majors
Jason D. Wittenbach

Department of Physics

Outstanding Senior Physics Major
Andrew T. Hartnett, Ronald Z. Lamberty

Outstanding Undergraduate Research Award
Edward R. White

Department of Preprofessional Studies

The Lawrence H. Baldinger Award
Adam J. Gadzinski, Stephen A. Currie

The Samuel J. Chmell, M.D., Award
Sunni L. Olding, Pable J. Diaz-Collado

The Patrick J. Niland, M.D., Award
F. Joseph Real III

The Rev. Joseph L. Walter, c.s.c., Award
William M. Sullivan

At the second annual COS JAM, **Alec Hirschauer** discussed his research on supernova remnants and shocked molecular clouds.

Undergraduate Researchers Present Their Results

The second College of Science Joint Annual Meeting (COS JAM) on May 2 brought more than 70 undergraduate students, almost twice as many as last year, to present the results from their original research to faculty and fellow students who filled the lecture halls, classrooms, and poster-lined Galleria of the Jordan Hall of Science. The event was part of the first University-wide Undergraduate Scholars Conference that showcased the research, scholarship, and creative endeavors of over 200 students from across campus.

Physics major **Andrew Hartnett** presented research that could lead soon to a far smaller, cheaper proton accelerator by using superconducting magnets. That would make proton therapy for treating cancer far more available in hospitals, because the handful of systems now in place cost nearly $100 million and weigh 200 tons. Hartnett's research involves using a set of bars to channel the proton beam toward the cancer when it leaves its orbit.

At a poster in the Galleria, biochemistry major **Christopher Mariani** explained his research that could help treat Niemann-Pick disease, a rare disease that prevents the metabolism of lipids and cholesterol within cells. The compound FM1-a-13 has been shown to lower cholesterol in cells with Niemann-Pick. Present work involves producing analogs of FM1-a-13 in search of improved biological activity.

In a classroom for mathematics presentations, **Marianne Beyer**, a double major in finance and mathematics, presented her work on ordinary differential equations that can be solved to determine an investor's optimal consumption and investment in stocks and bonds per period over a lifetime. She altered an equation discovered in 2004 that occasionally allowed for the return on risky stocks to be lower than the return on safe bonds. The new model, which eliminates that possibility, assumes that the investor lives to infinity and has exactly no money at death. Further research can show more realistic investing conditions using the equation.

In a lecture on biology, environmental sciences major **Michael McCann** presented his analysis of ways to control Eurasian watermilfoil, an invasive plant in lakes that the state now spends about $1 million a year to control. McCann presented two 10-year plans for attacking the problem. An aggressive approach would cost $7 million more (equivalent, he said, to 15 cents on each fishing license for 10 years) and control the pest at acceptable levels. A targeted approach, based on the current budget, would reduce the pest to acceptable levels in 58 percent of the lakes, the larger ones that account for 93 percent of the lake surface area. However, the watermilfoil in remaining ponds could be the source of new invasions.

In all, there were 23 research projects in biology, 24 in chemistry and biochemistry, 18 in physics, and seven in mathematics. The number of College of Science undergraduates who participate in research has more than doubled since 2000.

ND*e*RC Brings Research to the K–12 Classroom

Top left: NDeRC BioEYES educator **Anita Beebe** excites students to discover science. *Right:* Fifth graders at Kennedy Primary observe embryonic development through microscopes.

The "Partnering for Education and Research" forum sponsored by the Notre Dame *e*xtended Research Community (ND*e*RC) attracted 120 local K–12 teachers last December and led 50 teachers to apply for the in-class BioEYES activity. Half of those teachers, with 80 classrooms and some 1,600 students, will participate this year (2008–09), and the other half will join next year, making the outreach comparable in size to the original BioEYES in Philadelphia.

BioEYES, developed by curriculum specialist Jamie Shuda of Thomas Jefferson University, involves breeding zebrafish in the classroom, observing embryonic development through the transparent sac, and explaining the genetic effects of cross-breeding the fish, such as the red-eyed albino with the wild zebrafish. Teachers performed the activity at an NDeRC workshop in June. The local BioEYES activity started with a pilot at three schools last year.

James Whitcomb, a fourth-year graduate student who studies immunology with Mary Ann McDowell, professor of biological sciences, along with Jill Dzurisin, a third-year graduate student in the Department of Chemistry and Biochemistry who studies cell biology with faculty mentor Holly Goodson, collaborate with the K–12 teachers. The two graduate students typically launch the activity with the teachers at the beginning of the week and return to help throughout the week. Whitcomb and Dzurisin are two of seven graduate fellows working with ND*e*RC.

Patrick Mooney, a professional specialist in the Department of Physics, says the activity fosters ND*e*RC's goal of "mutual enculturation," taking university researchers into the classroom and bringing K–12 teachers into the university environment in order to bridge a gap between the teaching and research university and the K–12 classroom. Mooney is project coordinator of ND*e*RC, which is a National Science Foundation Graduate Teaching Fellows in K–12 Education (GK–12) project.

K–12 biology teachers also perform such laboratory techniques as polymerase chain reactions (PCR) and bacterial transformations. Physics teachers in a Jordan Hall of Science lab conduct classic experiments, including the Rutherford scattering experiment and the single-slit and double-slit experiments. Meanwhile, the graduate fellows receive training in pedagogy, including a study of brain development to help make lessons age-appropriate for students. BioEYES, for example, has different levels designed for 4th, 7th, and 10th grades.

Other ND*e*RC activities are astrophysics, particle physics, atomic imaging, bioinformatics, and robotics. Additional graduate fellows include Brighid Corcoran, advised by Marya Lieberman, and Annette Raigoza, advised by Alex Kandel, both in the Department of Chemistry and Biochemistry; Joseph Ribaudo, advised by Chris Howk, and Doug Berry, advised by Colin Jessop, both in the Department of Physics; and Ryan Connaughton in the Department of Computer Science and Engineering.

Faculty Promotions

In the Department of Biological Sciences, **Michael Ferdig** was promoted to associate professor with tenure.

In the Department of Physics, **Boldizsar Jankó** was promoted to full professor. **Peter Garnavich** was promoted to full professor with tenure.

In the Department of Chemistry and Biochemistry, **Bradley Smith** was promoted to an endowed professorship, the Emil T. Hofman Chair in Chemistry and Biochemistry. **Patricia Clark** was promoted to associate professor with tenure.

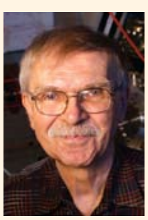
Faculty Accolades

JinHo Bang, postdoctoral research associate in the Radiation Laboratory, received the 2008 Piper Awards for outstanding research in inorganic chemistry from the Department of Chemistry of University of Illinois at Urbana-Champaign.

Seth Brown, associate professor of chemistry and biochemistry, received the 2008 Shilts/Leonard Teaching Award from the College of Science. His award is mentioned earlier in this issue.

Frank Castellino, the Kleiderer-Pezold Professor of Biochemistry and director of the Keck Center for Transgene Research, has been selected as the recipient of the 2008 WYETH-ISFP Prize. The prize is given to investigators who have made outstanding contributions to the field of fibrinolysis, proteolysis, and thrombolysis. He was selected by an international jury composed of members selected from the advisory board of the International Society for Fibrinolysis and Proteolysis and from previous prizewinners. The 2008 WYETH-ISFP Prize is generously sponsored by WYETH, in a continual effort to promote and stimulate high quality research in the field of fibrinolysis and proteolysis. Castellino received the $10,000 prize and delivered an honorary plenary lecture at the 19th International Congress on Fibrinolysis and Proteolysis in Vienna, Austria, July 6–10, 2008.

Malgorzata Dobrowolska-Furdyna, professor of physics, received the 2008 Rev. Edmund P. Joyce, C.S.C., Award for Excellence in Undergraduate Teaching. The award honors faculty members who have had a profound influence on undergraduate students through sustained exemplary teaching at Notre Dame.



Jacek Furdyna, the Marquez Chair in Information Theory and Computer Technology and professor of physics, and **Walter Johnson** and **Neal Cason**, emeriti professors of physics, were selected by the American Physical Society to receive the inaugural Outstanding Referee Award on March 10, 2008. This highly selective, lifetime award recognizes scientists who have been exceptionally helpful in assessing manuscripts for publication in APS journals including *Physical Review Letters, Physical Review,* and *Modern Physics*. The American Physical Society is the world's largest professional body of physicists, representing over 45,000 physicists in academia and industry in the United States and internationally.

Peter Garnavich, professor of physics, was a featured guest on National Public Radio on March 17, 2008, when he answered questions regarding the Large Binocular Telescope (LBT), located in southeastern Arizona, which uses two massive primary mirrors mounted side-by-side.

Michael Hildreth, associate professor of physics, received the 2008 Rev. Edmund P. Joyce, C.S.C., Award for Excellence in Undergraduate Teaching. The award honors faculty members who have had a profound influence on undergraduate students through sustained exemplary teaching at Notre Dame.

Leticia Llarrull, a postdoctoral research associate in the Department of Chemistry and Biochemistry, was named a 2008 Pew Latin American Fellow in Biomedical Sciences. Llarrull's research in the Mobashery laboratory has applications to Methicillin-resistant *Staphylococcus aureus* (MRSA), which has emerged globally as an important pathogen that is resistant to all classes of commercially available beta-lactam antibiotics. As a Pew Fellow, Llarrull will receive $60,000 of compensation from the Pew Charitable Trusts over two years for her research and training, and $35,000 for equipment to set up her own research laboratory when she returns to Argentina. She is one of only 10 Latin American Fellows nationally.

David Lodge, professor of biological sciences, was featured in a documentary of the American Museum of Natural History. The film, which includes footage of his research team conducting fieldwork at UNDERC-East, highlights his invasive species research. In addition to screenings at the AMNH, the film will also be shown at more than 40 museums and science centers.

Thomas Nowak, professor of chemistry and biochemistry, received the Grenville Clark Award, honoring volunteer activity and public service that advances the cause of human rights, to which Grenville Clark devoted his life. Nowak assists refugee families, those released from prison, and the homeless through the Catholic Worker House. The award was presented at the President's Dinner on May 20, 2008.

Victoria Ploplis was elected to be a Council and Scientific Advisory Board member of the International Society of Fibrinolysis and Proteolysis until 2014. Council and advisory members are involved in the organization of future meetings and in establishing policies of the society. The objectives of the society include the furtherance of scientific research relating to fundamental and medical aspects of fibrinolysis, proteolysis, and thrombolysis. At present, the ISFP has 250 members representing 35 countries.

W. Robert Scheidt, the William K. Warren Professor of Chemistry and Biochemistry, received the 2008 Hans Fischer Career Award in Porphyrin Chemistry, a lifetime achievement award, at the Fifth International Conference on Porphyrins and Phthalocyanines in Moscow in July. He has been doing research on porphyrin molecules since he came to Notre Dame in 1970. Scheidt gave an address titled "Explorations in Metalloporphyrin Stereochemistry, Physical Properties and Beyond" when he accepted the award.

Dennis Snow, professor of mathematics, received the Thomas P. Madden Award for outstanding teaching of first-year students. He is known for "the clarity of his thought and the imagination he utilizes in keeping students excited about mathematics." Snow is also known for displaying his musical talents by playing guitar at campus Masses.

Carol Tanner, professor of physics, has been appointed to a three-year appointment as secretary/treasurer of the Division of Atomic, Molecular, and Optical Physics of the American Physical Society. The division, which was founded in 1943, was the first division of the American Physical Society. Its central focus is fundamental research on atoms, simple molecules, electrons, and light, and their interactions. Professor Tanner held the Clare Booth Luce Chaired Assistant Professorship from the Henry Luce Foundation from 1990 to 1995. In addition, Prof. Tanner is the recipient of the Presidential Faculty Fellow Award (1992) and the University of Notre Dame Kaneb Teaching Award (2001). She has been a Fellow of the American Physical Society since 2002.

Anthony Trozzolo, the Charles L. Huisking Professor Emeritus of Chemistry, was presented with the 2008 UNICO National Marconi Science Award in Chicago on March 8, 2008. Trozzolo is a prolific inventor, with over 31 U.S. and foreign patents. A world-renowned authority on photochemistry, Trozzolo has focused his lifelong research efforts on the creation and detection of reactive intermediates. Applications of this area of research are numerous, including glow-in-the-dark inks and forensic analysis. UNICO National recognizes outstanding Italian American scientists who have made significant contributions to the field of science during their lifetime.

Student Accolades

UNDERGRADUATE STUDENTS

Adam Boocher, an honors mathematics major, received numerous awards, including the College of Science Dean's Award, the National Science Foundation Graduate Research Fellowship Award, the Senior G.E. Prize for Honors Mathematics Majors, and the George Kolettis Award in Mathematics.

Patrick Brown, now a senior, received the 2008 Norbert Wiech Award. The award is given by the Department of Chemistry and Biochemistry to recognize outstanding achievements of a junior.

Jack Enyeart, **Samuel Hovland**, and **Peter Kelly** were awarded the Norman and Beatrice Haaser Mathematics Scholarships for 2008. The scholarships, made possible by the generosity of the late Professor and Mrs. Haaser, are awarded to worthy, needy students majoring in mathematics.

Brittany Faron, Ashley Farrington, Scott Hagan, Michael Hawking, Mark Hug, Liz Keating, Lauren Kummer, Giancarlo Santos, Susan Seago, Nicolle Shirilla '00, and **Trevor Turner** received stipends from the Dooley Society to serve on medical missions during summer 2008. Their awards assisted with covering expenses associated with participation in an international medical mission project, consistent with the legacies of Dr. Tom Dooley and Notre Dame medical alumni now working in numerous countries around the world.

Adam Gadzinski received the 2008 Department of Physics Citizenship Award. He received numerous other awards and recognitions, including the College of Science Dean's Award.

Sarah Pastorek received the J & C Sophomore Award in Mathematics for exemplary performance in mathematics classes by a sophomore, non-honors, math major female or minority student.

Christine Ritten earned first place, while **Andrew McConvey, Daniel Moeller,** and **Luke Ricci** earned second place in the R. Catesby Taliaferro Prize Competition for Sophomore Honors Mathematics Majors in spring 2008. Former students, colleagues, and friends of Dr. Taliaferro established this prize, which is awarded on the basis of an essay submitted by the student.

Kristina Sault, a physics major entering her junior year, has been selected by the Department of Defense (DOD) for a Science, Mathematics, and Research for Transformation (SMART) Scholarship. This highly competitive scholarship will pay her full tuition for the next two years, an annual "book allowance," and a two-year stipend of at least $22,000. The DOD offers this scholarship for service to individuals who demonstrate outstanding ability and special aptitude for a career in scientific and engineering research and product development, and who express an interest in career opportunities at DOD laboratories.

John Pardo and **Brooks Smith** received the Aumann Prize for First Year Students in Mathematics. The prize is given by Ms. Monika Caradonna in honor of her father, Prof. Georg Aumann, and is awarded competitively to a first-year honors mathematics student on the basis of recommendations made by the faculty.

GRADUATE STUDENTS

Matthew Becker, Matthew Bowers, Andrew Dreyfuss, Antonios Kontos, Georgios Magkotsios, and **Nan Sun**, graduate students in the Department of Physics, received 2008 Kaneb Teaching Assistant Awards.

Jake Beaulieu, a doctoral degree recipient in the Department of Biological Sciences, received one of four 2008 Eli J. and Helen Shaheen Graduate School Awards at the Graduate School commencement ceremony on May 17, 2008. The award recognizes the top graduating doctoral degree recipients across the University. Beaulieu was

Student Accolades *(continued)*

distinguished from the typical graduate student because of his exemplary motivation to succeed and his impressive amount of prior research experience in biogeochemistry.

Erin Daly has received an American Chemical Society Division of Organic Chemistry Predoctoral Fellowship sponsored by Merck Research Laboratories. The award will support her studies with Richard Taylor's research group, where she has been investigating the bioactive conformation of epothilones, a class of natural products that could be used to create cancer-fighting drugs.

Jozsef-Andras Libal received the 2008 Outstanding Graduate Dissertation Award for his dissertation titled "Simulation Studies of Non-Equilibrium Collective Phenomena in Colloids."

Matthew Meixner, graduate student in the Department of Physics, attended the 58th meeting of Nobel Prize Winners in Physics in Lindau, Germany from June 29 to July 4, 2008. Some 500 young students came from around the world to listen to the Laureates' lectures and to engage in discussions with them. Intermediaries from universities and research institutions annually select participants based on strict criteria.

Chris Porter and **Stacy Hoehn** both received 2008 Outstanding Graduate Student Teacher awards from the Kaneb Center for Teaching and Learning. The award is given to graduate students, selected by their department, who demonstrate excellence in the classroom, laboratory, or other instructional capacity.

Sherri Smith has won a three-year post-doctoral fellowship worth $70,000 per year at the Pasteur Institute in Paris, which was founded by Louis Pasteur in 1887. She is studying the parasite *Entamoeba histolytica*. The research involves characterizing the immune response during infection with the amoeba and determining the role potential virulence factors play in the elicited immune response. At Notre Dame, Smith worked with Kristin Hager, assistant professor of biological sciences for her Ph.D., studying protein transport in the parasite *Toxoplasma gondii*.

Alumni

Laura A. Banaszynski, who graduated in 2000 with a bachelor's degree in chemistry from the University of Notre Dame, has been named the winner of the 2009 Nobel Laureate Signature Award for Graduate Education in Chemistry for her work with Dr. Thomas J. Wandless at Stanford University. Banaszynski currently holds the Angelo Family Fellowship of the Damon Runyon Cancer Research Foundation at Rockefeller University. She is a postdoctoral fellow in C. David Allis' laboratory of chromatin biology and epigenetics and is investigating how histone modifications regulate gene expression and maintain genome stability, work that could have significant implications for cancer diagnosis and therapeutics. The Nobel Laureate Signature Award for Graduate Education in Chemistry is sponsored by Mallinckrodt Baker Inc.

Robert Lumpkins, director of Ecolab Inc. and chair of the board of the Mosaic Company, was appointed to the board of directors of Webdigs. During his 38 years with Cargill, Lumpkins served as chief financial officer, vice chairman, and later board member. He earned a bachelor's of science in mathematics in 1966 from the University of Notre Dame and an M.B.A. from the Stanford Graduate School of Business.

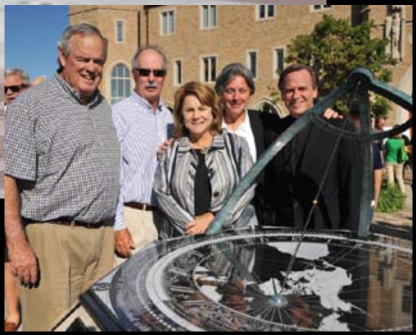
Salvatore LaPilusa, an orthopedic surgeon who earned a bachelor's of science from the University of Notre Dame in 1941, received the Rev. Edward Frederick Sorin, C.S.C., Award from the Alumni Association during Reunion 2008 for his distinguished service to the University. LaPilusa established an endowed scholarship in memory of his wife, Lorraine, which has benefited more than 70 undergraduate students. He funded the physiology wing in the Jordan Hall of Science. He now travels to Third World countries to work with young orthopedic doctors and learn about their cultures.

Sr. Katherine Seibert, medical director and internist at Hudson River HealthCare's Community Health Center, was recognized as Person of the Year by the Notre Dame Club of New York. The award is given to an alumnus who has exhibited outstanding leadership in the community. Seibert has been a Sister of Charity of New York for 54 years. She earned an M.S. in biology in 1967, and a Ph.D. in microbiology in 1973, both from the University of Notre Dame. While doing cancer research at the Lobund Laboratory, she decided to specialize in oncology. She completed medical school, was an oncology fellow at the National Cancer Institute, and served as chief of oncology at several hospitals in New York City. She currently focuses on the well-being of every patient at the health center.

Philip Volpe, U.S. Army Brig. Gen., 1977 University of Notre Dame graduate, board-certified family physician, and director of health services at Fort Bragg, N.C., received the Rev. William Corby, C.S.C., Award honoring distinguished military service. The award was presented during halftime of the Notre Dame-Navy football game Nov. 3, 2007.

Undergraduate Instruction and Research

Throughout the 40 specialized laboratories in the Jordan Hall of Science, undergraduate students are learning basic research techniques and developing critical-thinking and problem-solving skills. Over the summer and during the academic year, students apply their knowledge in research laboratories across the country and present their results at events such as the Fall Undergraduate Research Symposium.



Joseph O'Neill III '67, Kevin O'Neill '69, Jan O'Neill, designer William Andrewes. and Fr. John Jenkins, C.S.C.

The Longitude Dial is a solar clock accurate to the nearest minute, showing exactly where the viewer is in time and space. With the University of Notre Dame in the center of the map, the dial has been designed for the exact point on Earth where the University is located.

The dial is based on an idea published in Nuremberg by Franz Ritter in 1607 in which a map was projected like a sun-dial, so that lines of longitude served as hour lines. Ritter's map was adopted as an aid to navigation for plotting sea routes. One of its special features is that a straight line drawn between any two points on the map represents the shortest distance between them.

The commissioning was made possible through the generosity of Jan and Joseph I.O'Neill III '67 in honor of the memory of Joe's roommate Michael Flynn '67 and his brother Kevin O'Neill '69.

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