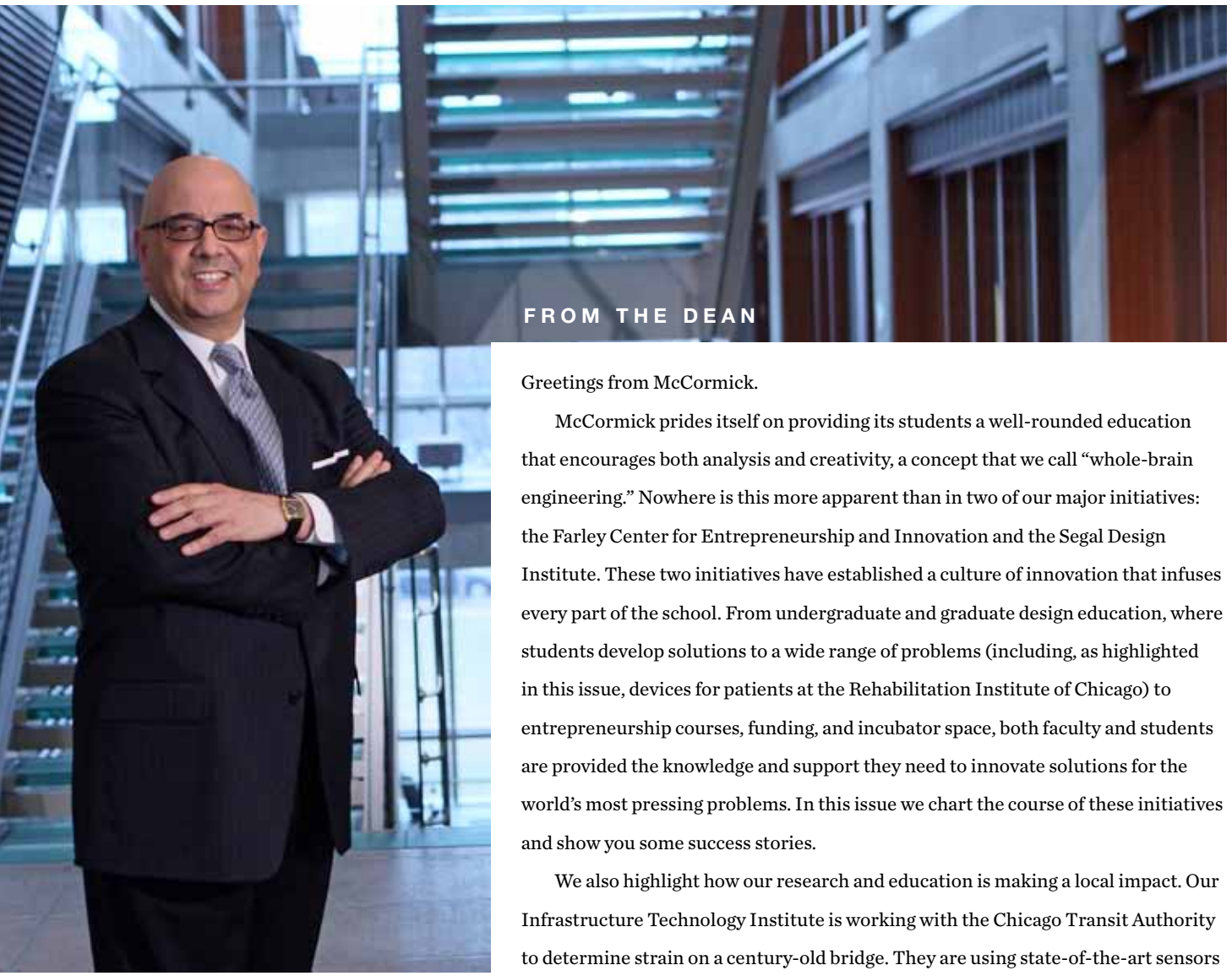
McCormick

magazine | spring 2011

ARCHITECTURE IN BERLIN

STUDENTS LEARN FROM THE MASTERS

Robert R. McCormick School of
Engineering and Applied Science
Northwestern University



FROM THE DEAN

Greetings from McCormick.

McCormick prides itself on providing its students a well-rounded education that encourages both analysis and creativity, a concept that we call "whole-brain engineering." Nowhere is this more apparent than in two of our major initiatives: the Farley Center for Entrepreneurship and Innovation and the Segal Design Institute. These two initiatives have established a culture of innovation that infuses every part of the school. From undergraduate and graduate design education, where students develop solutions to a wide range of problems (including, as highlighted in this issue, devices for patients at the Rehabilitation Institute of Chicago) to entrepreneurship courses, funding, and incubator space, both faculty and students are provided the knowledge and support they need to innovate solutions for the world's most pressing problems. In this issue we chart the course of these initiatives and show you some success stories.

We also highlight how our research and education is making a local impact. Our Infrastructure Technology Institute is working with the Chicago Transit Authority to determine strain on a century-old bridge. They are using state-of-the-art sensors that provide insight into the structural health of the bridge.

On our cover you can see a photo from our Architectural Engineering and Design Program's recent study abroad trip to Berlin. Students spent a week there in the offices of world-renowned architect Helmut Jahn, gaining a unique perspective on architecture and engineering while receiving feedback from Jahn and other well-known stakeholders in the architecture world. The program, now three years old, is another example of McCormick's commitment to design and innovation: students in the program are using their background in engineering and their additional studies in the structure and creativity behind buildings to forge their own paths in the building business.

As always, I welcome your feedback.

Julio M. Ottino, Dean | April 2011

McCormick magazine is published by the Robert R. McCormick School of Engineering and Applied Science, Northwestern University, for its alumni and friends.

On the cover: A student in McCormick's Architectural Engineering and Design Program works on sketches in the Berlin office of architect Helmut Jahn. See story on page 22.

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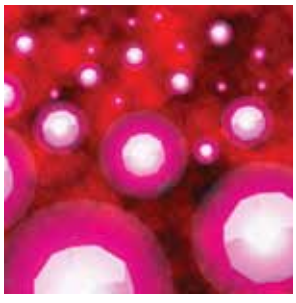

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McCormick news

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INNOVATIVE NEWS LAB LAUNCHED

A one-of-a-kind lab aimed at reinventing journalism for the digital age has been created at Northwestern. The Knight News Innovation Laboratory will bring together journalists and computer scientists to accelerate local media innovation by creating new digital tools, building partnerships with media organizations, and expanding the media innovation community. The McCormick School is collaborating on the venture with the Medill School of Journalism and the John S. and James L. Knight Foundation.

The lab—the first of its kind in the country—is funded by a four-year, $4.2 million grant from the Knight Foundation. Its mission is to improve the news and information people use to run their communities and their lives. It will partner with Chicago-area media organizations to test, deploy, and refine technologies that help them create and package content, engage audiences, and improve their capacity to produce local news and information.

The Knight Lab's work will be carried out under the auspices of the Medill-McCormick Center for Innovation in Technology, Media, and Journalism, created in 2009. **Kris Hammond** (above, far left), professor of electrical engineering and computer science, and **Larry Birnbaum** (above, center), associate professor of electrical engineering and computer science, provide the McCormick leadership for the center, along with Owen Youngman and Rich Gordon from Medill.

Julio M. Ottino, dean of the McCormick School, says, "Northwestern is a university that embraces interdisciplinary work, and the McCormick School is a place where computer scientists and experts in areas such as journalism can collaborate to shape the future."

McCORMICK RISES IN RANKINGS

The McCormick School has improved its position in the rankings produced by *US News & World Report* magazine. McCormick was recognized as having the 13th best undergraduate engineering program in the country, and its graduate program ranking climbed to 20th. Rankings of graduate programs were particularly strong, with six departments ranked in the top 20 nationally. McCormick also fared well in the recent rankings by the National Research Council. Read more at www.mccormick.northwestern.edu/news.

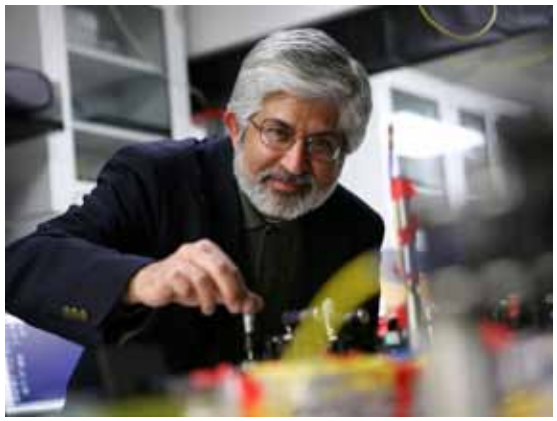
STRETCHABLE ELECTRONICS SIMPLIFY CARDIAC THERAPY

As an alternative to open-heart surgery, cardiologists now use catheters to eliminate damaged heart tissue in certain patients, such as those with arrhythmias. This procedure can also be protracted and painful, as many catheters with many different functions must be inserted into the patient.

Now an interdisciplinary team including researchers from the McCormick School has developed a single multifunctional catheter that makes a minimally invasive technique for heart surgery even better. This tool for cardiac ablation therapy has both diagnostic and treatment capabilities and combines all necessary medical devices into a standard balloon catheter: a device for eliminating damaged tissue using heat, temperature and pressure sensors, and an electrocardiogram sensor.

The stretchable electronics that make it possible were developed by **Yonggang Huang,** Joseph Cummings Professor of Civil and Environmental Engineering and Mechanical Engineering, and John Rogers of the University of Illinois at Urbana-Champaign. "The use of one catheter to achieve all these functions will significantly improve clinical arrhythmia therapy by reducing the number of steps in the procedure, thereby saving time and reducing costs," says Huang. Read more at www.mccormick.northwestern.edu/news.

NEW SWITCHING DEVICE COULD HELP BUILD ULTRAFAST QUANTUM INTERNET



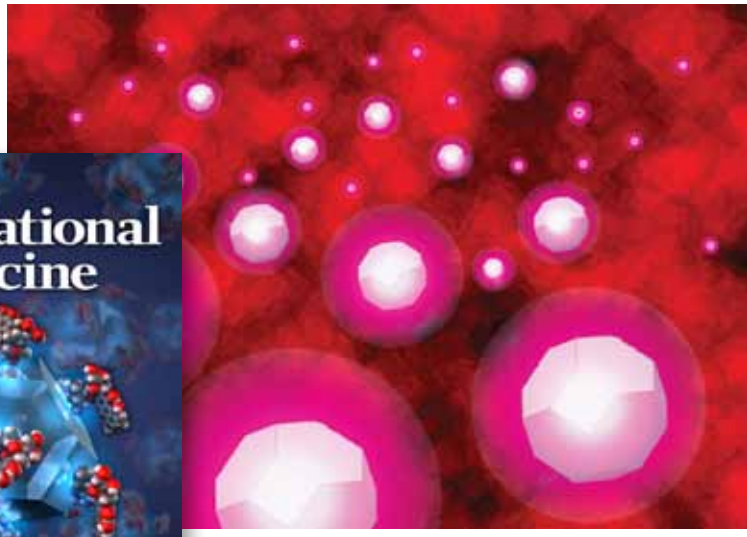
Northwestern researchers have developed a new switching device that takes quantum communication to a new level. The device is a practical step toward creating a network that takes advantage of the mysterious and powerful world of quantum mechanics.

A demonstration of the first all-optical switch suitable for single-photon quantum communications was published by the journal *Physical Review Letters*. The switch could be used in achieving two goals of the information technology world: a quantum Internet, where encrypted information would be completely secure, and networking superfast quantum computers.

Prem Kumar, AT&T Professor of Information Technology and senior author of the paper, says, "My goal is to make quantum communication devices very practical. We work in fiber optics so that as quantum communication matures it can easily be integrated into the existing telecommunication infrastructure."

The switch would enable a common transport mechanism, such as the ubiquitous fiber-optic infrastructure, to be shared among many users of quantum information. Such a system could route a quantum bit, such as a photon, to its final destination just as an e-mail is routed across the Internet today.

TINY GEMS TAKE BIG STEP IN CANCER BATTLE



Resistance to chemotherapy drugs contributes to treatment failure in more than 90 percent of metastatic cancer cases. Overcoming this hurdle would significantly improve cancer survival rates. **Dean Ho,** associate professor of biomedical engineering and mechanical engineering, believes a tiny carbon particle called a nanodiamond (above) may offer an effective drug-delivery solution for hard-to-treat cancers.

In vivo studies of liver and breast cancer models conducted by Ho and a multidisciplinary team of scientists, engineers, and clinicians found that a normally lethal amount of a chemotherapy drug when bound to nanodiamonds significantly reduced the size of tumors in mice with no toxic effects on tissues and organs. Survival rates also increased.

This is the first work to demonstrate the significance and translational potential of nanodiamonds in the treatment of chemotherapy-resistant cancers. The results were published in the journal *Science Translational Medicine*. Read more at www.mccormick.northwestern.edu/news.

TRANSPORTATION SECRETARY HONORED AT SYMPOSIUM

Former US Secretary of Transportation and White House chief of staff Samuel K. Skinner received the David F. Schulz Award for Outstanding Public Service in Transportation and Infrastructure Policy from Northwestern last November. The honor was presented at the fourth annual William O. Lipinski Symposium on Transportation Policy.

The symposium, titled "Public Transit for Chicago: A Sustainable Ride to the Future," brought together transportation leaders and policy makers from across the country to address the mass transit challenges and opportunities facing the region and nation. Northwestern's Infrastructure Technology Institute sponsored the event, named for former Congressman William O. Lipinski of Chicago. Lipinski hosted the conference and presented Skinner with the Schulz Award, named for the late Dave Schulz, founding director of the institute.

In addition to Lipinski, participants at the symposium included University President Morton Schapiro; Rep. Peter DeFazio (D-OR), Rep. Daniel Lipinski (D-IL); Richard L. Rodriguez, president of the Chicago Transit Authority; Michael J. Madigan, speaker of the Illinois House of Representatives; and John Cullerton, president of the Illinois Senate.

Joseph Schofer, Jo Ann Schulz, Samuel Skinner, and William Lipinski

McCormick
IN THE MEDIA

CLASSROOM CLICKERS FEATURED IN *NEW YORK TIMES*

It's a problem in nearly every classroom: students spend class time checking their e-mail on their phones or laptops. Now, some undergraduates must use similar technology to prove that they are actually paying attention. In **William White**'s Organizational Behavior class, each student has a clicker that is used to register attendance, take quizzes, and answer questions posed by White, a professor of industrial engineering and management science. "They should walk in with them in their hands, on time, ready to go," he said in a November **New York Times** article about the clickers (www.nytimes.com/2010/11/16/education/16clickers.html).

White is one of three dozen professors across the University who use the technology. The article says, "The greatest impact of such devices—which more than a half-million students are using this fall on several thousand college campuses—may be cultural: they have altered, perhaps irrevocably, the nap schedules of anyone who might have hoped to catch a few winks in the back row and made it harder for them to respond to text messages, e-mail, and other distractions."

Wisconsin Public Radio and **NBC Chicago** also reported on this story.

STUPP IN *FAST COMPANY*

The February issue of **Fast Company,** a business magazine that focuses on innovation in technology, leadership, and design, included an article profiling **Samuel Stupp,** Board of Trustees Professor of Materials Science and Engineering, Chemistry, and Medicine and director of the Institute for Bionanotechnology in Medicine. The article, "How Samuel Stupp Is Rebuilding Your Body, One Molecule at a Time," concerned Stupp's innovations in regenerative medicine. It featured comments by Ramille Shah, assistant professor of materials science and engineering and orthopaedic surgery, and Monica Olvera de la Cruz, professor of materials science and engineering and chemical and biological engineering. See www.fastcompany.com/magazine/152/molecular-healing.html.

LEWIS OFFERS INSIGHT ON JAPAN'S NUCLEAR CRISIS

As the world attempted to understand the nuclear crisis following the devastating earthquake and tsunami in Japan, the media frequently turned to **Elmer Lewis,** professor emeritus of mechanical engineering. He was cited in reports in the **Wall Street Journal,** the **Los Angeles Times,** the **Christian Science Monitor,** MSNBC, and hundreds of other outlets.

Lewis is the author of the textbooks *Nuclear Power Reactor Safety* and *Fundamentals of Nuclear Reactor Physics,* among other publications. His research has focused on the broad problems of dealing with the physics, safety, and reliability of nuclear systems as well as computational methods for neutron transport.

"The combination of an earthquake of unprecedented intensity followed immediately by a tsunami of historic proportions in Japan has resulted in the most serious nuclear reactor accidents in decades," Lewis said. "Understandably, the uncertainty associated with the further progression of the partial melting of the reactor cores has engendered a great deal of psychological trauma as well as media attention. However, it appears that loss of life to the public—if any—caused by the radiation releases from these accidents will be minuscule when compared with the thousands of deaths caused by the earthquake and tsunami."

Lewis also reassured Americans concerned about radiation exposure: "I think it's exceedingly improbable—I'd say impossible—that this accident would deliver any detectable amount of radiation at ground level in the United States."

WATCH THE LATEST McCORMICK EVENTS ONLINE

From IBM's Ginni Rometty to composer Tod Machover to SpaceX president Gwynne Shotwell, McCormick has had a year full of great speakers. You can view events such as the Dean's Seminar Series online at http://video.mccormick.northwestern.edu.

READ MORE AT WWW.MCCORMICK.NORTHWESTERN.EDU

McCORMICK HONORS

Samantha Dale Strasser ('11) received a 2011 Churchill Scholarship, one of the most competitive scholarships for American undergraduates. This is the third consecutive year that Northwestern students have received the honor.

Roshni Barot ('11) was named the Co-op Student of the Year by the Cooperative and Experiential Education Division of the American Society of Engineering Education. Barot, who was also named Northwestern's Co-op Student of the Year, was employed at Baxter Healthcare Corporation.

Malcolm MacIver, associate professor of biomedical and mechanical engineering, received a 2010 Presidential Early Career Award for Scientists and Engineers, one of the highest science honors given by the US government. He was recognized for his interdisciplinary work on the biomechanical and neural basis of animal intelligence (see story on pages 28–31) as well as for innovative outreach efforts that include writing a blog for *Discover* magazine, participating in interactive art installations, and advising on Hollywood science-fiction projects such as *The Avengers* (2012), and *Caprica,* a drama on the Syfy channel. Eighty-five scientists received the award last year.

Vinayak Dravid and **Chris Wolverton,** professors of materials science and engineering, have been elected fellows of the American Physical Society. Dravid (left) was honored for seminal contributions to the materials physics of functional materials through the use of state-of-the-art electron microscopy techniques. Wolverton was cited for innovative contributions to atomic- and multiscale computational materials physics, particularly in the area of phase stability of materials.

Chad A. Mirkin was elected to the Institute of Medicine, one of the highest honors in the fields of health and medicine in the United States. He is the first person at Northwestern and only the tenth in the world to be elected to all three branches of the National Academies. Mirkin is the George B. Rathmann Professor of Chemistry and professor of medicine, chemical and biological engineering, biomedical engineering, and materials science and engineering, as well as director of Northwestern's International Institute for Nanotechnology.

Read more at www.mccormick.northwestern.edu/news.

McCORMICK LAUNCHES NEW CHINESE WEBSITE

In an effort to communicate with the families of potential applicants in China, McCormick has launched a Chinese version of its website. The site offers information on McCormick's high rankings and distinguished reputation, its graduate and PhD programs, job placement data, and prominent Chinese faculty and alumni. *chinese.mccormick.northwestern.edu*

McCormick has also launched five web sites that focus on new **research initiatives** that emerged from the New Opportunities Workshops sponsored by the Dean's Office for faculty members.

- **Engineering markets**
  This initiative explores how techniques from computer science, information theory, and economics can be combined to understand and improve the large-scale automated markets for the exchange of goods and services made possible by the Internet. *markets.mccormick.northwestern.edu*
- **Health care engineering**
  This program draws on faculty from McCormick and the Feinberg School of Medicine to apply engineering methods and problem-solving skills to important problems in health care. *he.northwestern.edu*
- **Humanitarian logistics**
  Humanitarian logistics is the coordination of people, organizations, and materials to deliver goods and services to people in need. *hl.mccormick.northwestern.edu*
- **Multifunctional infrastructure materials**
  Northwestern researchers are exploring technologies for building sustainable infrastructure, from self-healing concrete and steel to CO_2-absorbing cement and asphalt. *mim.mccormick.northwestern.edu*
- **Systems and synthetic biology**
  Synthetic biology seeks to harness biology to meet pressing societal needs—from next-generation biofuels and renewable "green" chemicals to industrial feedstocks and programmable biological therapies. *.synbio.northwestern.edu*

Entrepreneurship + Design

Two areas—and the intersections between them—are defining McCormick as an innovator in engineering education

The Farley Center for Entrepreneurship and Innovation

Building a culture of entrepreneurship

Next to the Red Line "L" tracks in Chicago's Lakeview neighborhood you'll find the makeshift one-room office of Datascope Analytics. Its contents are sparse: a conference table, a television, two computers, a few small appliances. The décor is minimal—white boards full of equations and ideas—except for one splash of color: the entrance wall is painted a color dubbed "Datascope Analytics orange" by the start-up's founders. Outside, a train rumbles by.

At the whiteboards or the computers on any given weekday are Datascope's cofounders, Dean Malmgren and Mike Stringer, the self-effacing Northwestern PhD graduates who founded the company because, as the name might suggest, they love analyzing large data sets. "It sounds kind of nerdy," Stringer admits.

Left: Students in the McCormick School's Ford Motor Company Engineering Design Center. *Photo by Andrew Campbell.* Right: Mike Stringer and Dean Malmgren of Datascope Analytics. *Photo by Sally Ryan.*

Two years ago they were students in the lab of Luis Amaral, professor of chemical and biological engineering, examining large communication networks and databases of scientific journals to figure out what information might be culled from them. (Malmgren also worked with Julio M. Ottino, professor in chemical and biological engineering as well as dean of McCormick.) This sort of large data analysis was an emerging research area at the time, and Malmgren and Stringer thought it might also be profitable. "Between e-mails and social networks, everyone is storing huge amounts of data," Stringer says. "We realized there was a lot of potential to use this data. We thought, 'This is what we like doing. We might as well start a business.'"

It turns out they were good at more than just analyzing data—they also knew how to communicate their results. They understood that static columns of figures and graphs couldn't accurately portray the complexity of their analysis, so they created what they call LivingReports™—websites with interactive graphics. "We wanted to change how research is communicated," Malmgren says.

Stringer and Malmgren were unlikely entrepreneurs. They'd spent most of their adult lives in academia—in the sciences, not in management school. Yet it turns out that instead of honing their business skills, they were cultivating something perhaps more important: a network they could turn to for help. When they were hatching their idea for a business, they met with Ottino, who sent them to Mike Marasco, the director of McCormick's Farley Center for Entrepreneurship and Innovation. That connection would turn them from two guys with an idea into business owners with a full-fledged, profitable company in less than two years. The center provided the support—office space, legal and business advice, networking opportunities—their idea needed to flourish.

Identifying viable opportunities

McCormick launched the Farley Center for Entrepreneurship and Innovation in 2007 with the goal of taking ideas in engineering and turning them into successful businesses. The need at Northwestern was clear: the few entrepreneurship courses offered at the time were continually oversubscribed, while many faculty and students who had created cutting-edge technology lacked the knowledge and resources to bring their ideas to market. In the last four years the Farley Center has dramatically expanded course offerings in entrepreneurship, created an incubator space for start-up businesses, allocated preseed funds for start-ups, and provided guidance to students and professors who wanted to make their ideas successful. In other words, it has made entrepreneurship an integral part of the McCormick culture.

"Engineering is more than just prototypes and research," says Marasco. "A design that never sells is not a great design. A product that never gets traction in the market is not a great product. The Farley Center gives students and professors the means to leverage an idea and build it into a company."

The center's first course, NUvention: Medical Innovation, was offered in 2008. The brainchild of a Northwestern medical student, it brought together 82 graduate and undergraduate students from four Northwestern schools (McCormick, the Kellogg School of Management, the Feinberg School of Medicine, and the School of Law) to develop medical devices and create business plans for the ideas (see *McCormick by Design* magazine, spring 2008). The students observed doctors and surgeons to determine where new devices and products were needed and were mentored by professors and industry leaders from across the country. When the course was over, the students had created several innovative medical devices and would eventually file 11 provisional patents.

"One of our keys is interdisciplinary, experiential learning," Marasco says. "McCormick had a number of case-based entrepreneurship courses, but we wanted to go beyond that. NUvention turned out to be a resounding success."

In fact, the NUvention courses have set a new standard in entrepreneurship education. The Farley Center has introduced two variations on that first course: NUvention: Web, involving the design and launch of online applications, and NUvention: Energy, in which energy research innovations from Northwestern and Argonne National Laboratory are developed into viable businesses. These courses

Michael Marasco, director of the Farley Center for Entrepreneurship and Innovation, teaching a NUvention class.
Far right: Zack Johnson, CEO of Syndio Social, in the start-up's office.
Photos by Sally Ryan.

are among the most popular at McCormick: this year they enrolled more than 160 students from nearly every school at the University.

"These courses bring together two areas that are key strengths at McCormick: entrepreneurship and product design and development," Marasco says. "You can learn about them through traditional academic approaches, but there's another level of learning associated with actually doing it. We're doing everything we can to simulate real-world experiences."

In some cases, the experience goes beyond simulation. One start-up that has emerged from NUvention is Adapt.ly, a service that allows businesses to buy ads simultaneously on multiple social network ad platforms. Cofounded by Nikhil Sethi (electrical engineering '10) last spring, the company has received its first round of venture capital financing. The founders went directly from the spring quarter NUvention course to the DreamIt Ventures incubator, which gave them $25,000 and three months to get their business up and running. At the end of that period, Sethi had the opportunity to pitch Adapt.ly to venture capitalists. Now the company has 15 employees and powers social ad campaigns for large agencies and brands.

"NUvention helped put the right ideas into our heads and pointed us in the right direction," Sethi says. "It showed us that we don't have to work for big software companies. There is a different way of doing things. We can create a business to rival them ourselves."

In addition to the NUvention courses, the Farley Center annually offers seven undergraduate and four graduate courses in entrepreneurship and advises four undergraduate student groups focused on for-profit and social entrepreneurship. "Through our courses, we're able to engage alumni, faculty, and students and empower them so they feel that entrepreneurship is a viable opportunity," Marasco says.

An incubator for innovation

When Malmgren and Stringer first met Marasco in July 2009, they were finishing up their degrees and thinking about starting what would become Datascope Analytics. Marasco told them about the Farley Center's incubator space in downtown Evanston, where Northwestern students starting a business can work rent-free while getting business and financial advice from the incubator's staff. A few minutes later, he invited them to hop in his car and take a look at the space. It wasn't pretty—two little offices with eight desks—but it provided a physical location and something money can't buy: legitimacy.

"When you are trying to get things started, it's nice to know that you have a place to work for a while and not have pressure to get out," Malmgren says.

Marasco helped them navigate paperwork, and an attorney at the incubator provided pro bono legal advice. With this help, Malmgren and Stringer were confident that their idea could be turned into a business. But how did they know it would be successful?

"We didn't—until we got our first client," Malmgren laughs. "We didn't have any marketing or advertising. We relied on referrals, and then we did a good job so our clients would hire us again. So far we've gotten repeat business from everyone we've worked with."

Among the company's first clients was the McCormick School of Engineering and Applied Science. Using data from the Thomson-Reuters ISI Web of Science, Datascope charted the number of collaborative scientific articles authored by faculty at McCormick and other schools at Northwestern. The resulting interactive graphics showed the strength and extent of collaboration at the University (see *McCormick* magazine, spring 2009).

> "A design that never sells is not a great design." MIKE MARASCO

That spirit of collaboration is evident at the incubator as well. There Malmgren and Stringer found not only potential clients but also potential partners—such as Zack Johnson, an undergraduate in Northwestern's School of Communication and CEO of Syndio Social.

Johnson's story shows that there is more than one way to become an entrepreneur at Northwestern. After taking a network analysis course with Noshir Contractor, the Jane S. and William J. White Professor of Behavioral Sciences and professor of industrial engineering and management sciences and of communication studies, Johnson realized he loved the math and science behind social networks and became a research assistant in Contractor's lab.

Johnson, who was already doing social media music marketing on the side, saw a business opportunity in Contractor's research. "I was interested in mapping and measuring how communication happens on a daily basis inside an organization," Johnson says. Contractor himself had done some consulting with his C-IKNOW

software (a web-based tool designed to map and measure social networks), but the time and bandwidth needed to turn his ideas into a full-fledged business were constrained by his research commitments. So, Johnson spent a quarter creating a business plan under the tutelage of Marasco and Bill White, professor of industrial engineering and management sciences.

"Three months later, we figured out the business plan," Johnson said. "We said, 'Yeah, let's give it a shot. Let's see what happens.'"

Since Contractor's research takes most of his time, he knew that he needed someone like Johnson—someone with an entrepreneurial spark—who could run day-to-day operations and build a viable business. "The Farley Center provided me with guidance about different models that faculty members could use to create businesses, which was helpful," Contractor says. "I chose a model that helped me engage just enough to keep me intellectually honest—to make sure that my research program continues to be responsive to questions that have real relevance in society."

Johnson set up shop in the Farley Center's incubator in summer 2009. "Just being able to get away from campus was huge," he says. "We had a small window that got two minutes of sunshine a day, but it was a place to go to work, and it makes you feel better about doing it."

Johnson says he also received guidance from the Farley Center's advisory board, many of whose members are active in industry (including James Farley ['50], whose James N. and Nancy J. Farley Foundation generously endowed the center). "A lot of people hit a wall because they don't have a network," Johnson says. "I know I can go to this group for help."

Using employee surveys and digital trace data like e-mails, Syndio Social looks at internal communication networks "to see how communication unfolds," Johnson says. "You get an emergent structure of what actually happens in a company." That, he says, can help managers see which employees are most trusted and how to make good teams.

Johnson met Malmgren and Stringer at the incubator. When one of Johnson's clients—Procter & Gamble—approached him about a project that was beyond Syndio Social's scope, he asked if Datascope wanted to collaborate. Procter & Gamble was interested in finding the best way to enact organizational change. Typically, if a company wants employees to use a new practice, it will ask managers whom they should train first—who could best spread the word and teach other employees. Procter & Gamble realized, however, that asking managers wasn't always the best way to identify the most trustworthy, influential people in the company.

Datascope and Syndio Social worked together for months to understand the network of influences within the corporation. Using Syndio's C-IKNOW software to survey thousands of employees, they found a set of highly influential people who were widely distributed throughout the organization, and they presented the data in one of Datascope's LivingReports. That allowed Procter & Gamble officials to model scenarios of how best to distribute information and whom to train. Procter & Gamble is already in talks with the two companies for future projects.

"It was a great example of how the Farley Center helped put two teams together," Johnson says. "Neither company could have done this project alone, but together we worked as a tight-knit team."

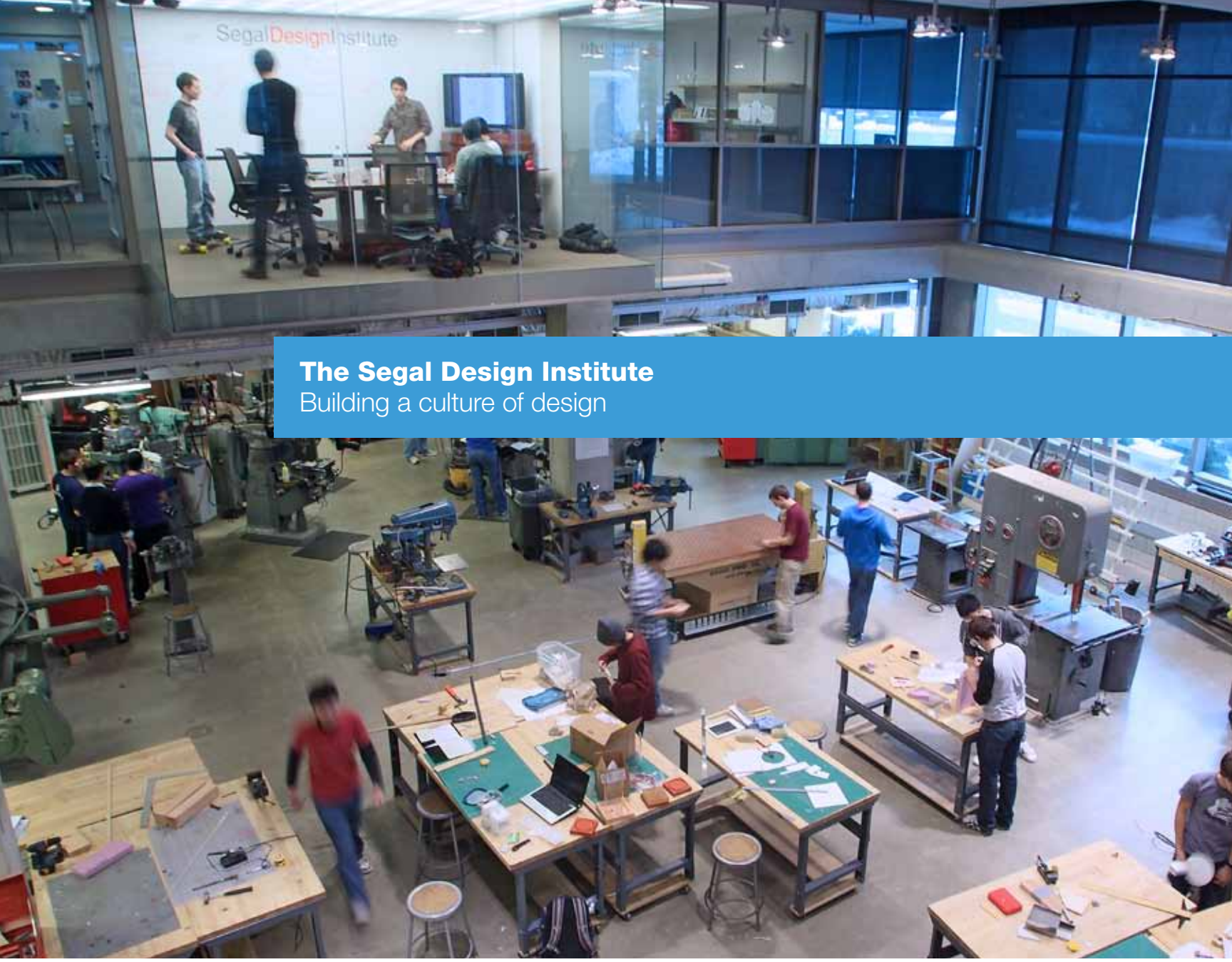
Using their first big successful project as a boost, both Datascope and Syndio Social have moved out of the incubator and into their own Chicago offices. Both have hired interns and co-op students through McCormick's career development office and look forward to helping the next generation of McCormick alumni to become successful entrepreneurs. Contractor says that one Syndio Social intern was even inspired to start her own business. "The Farley Center has had a ripple effect that goes beyond Syndio," he says.

Entrepreneurship for the future

The Farley Center continues to look for new and better ways to empower students and faculty. It has established certificate programs for undergraduate and graduate students, and it recently created the Farley Preseed Program, which allows alumni to invest in businesses that come out of McCormick courses or labs. There's a catch: investors must give at least a quarter of their profit back to the University. "It gives alumni an opportunity to invest very early on in new businesses," Marasco says. "And it truly highlights their commitment to the University." Farley board members began identifying potential investment projects this winter.

Since its inception four years ago, the Farley Center has grown alongside McCormick's Segal Design Institute to become a major asset for students, faculty, and alumni. It's that connection that makes the center so strong, Marasco says.

"Many engineering schools do both design and entrepreneurship," says Marasco. "I think we're unique in that we've really tried to integrate the two. Segal and Farley have put us at a different level. One of our missions is to empower our students to become entrepreneurs. We want them to know it's something they can do. Their core skill sets of design and analysis can be expanded into a successful business, and we'll show them how."



The Segal Design Institute
Building a culture of design

The three freshmen were given the task that nearly all students in McCormick's Engineering Design and Communication course sequence receive: create a device that betters the life of someone with a physical disability. In this case, how could they help a stroke survivor open bottles and jars using just one hand?

They started the way each group of students starts—by taking a sheet of paper and writing down every crazy idea they had. The ideas ranged from vague (some sort of device) to absurd (monkeys, aliens with laser beams). But when the team visited the Rehabilitation Institute of Chicago and observed a stroke survivor who had the use of only one hand to open bottles, they saw the significance of the problem. The man put the jar between his knees, under his arm, and tried to hold it with one part of his hand while twisting the top with his fingers. "We felt weird watching him

struggle," says Ted Stein (computer science '11). "We only went for one observation, but that was enough to know what we were doing was necessary."

The lessons Stein and his colleagues learned as freshman back in 2008—that good design fulfills a need, that design is ultimately for the greater good—are taught to students from their very first year at McCormick. Over the past 15 years, from the development of the first-year EDC classes and introduction of the Segal Design Institute to the creation of several graduate programs, design has become an integral part of the curriculum and culture at McCormick.

"It has made a big difference in how students think about themselves as engineers," says Bruce Ankenman, associate professor of industrial engineering and management sciences and director of undergraduate programs for the Segal Design Institute. "They think of themselves as designers, not as mathematicians. It's a different mindset."

Though design has always been an integral part of engineering, McCormick has pushed it to the forefront in the past decade. What was once the Institute for Design Engineering and Applications at Northwestern evolved into the Segal Design Institute in 2007 after Gordon and Carole Segal, founders of Crate & Barrel, made a significant donation to the school. Housed in the Ford Motor Company Engineering Design Center (built in 2005), the Segal Design Institute aimed to be a hub for design education and research across the University.

A key aspect of that effort was introducing students to design in their freshman year during the required two-quarter EDC course sequence. There, students get their first taste of McCormick's human-centered design curriculum. "Our students learn not only how to solve problems but also how to frame them," says J. Edward Colgate, the Allen K. and Johnnie Cordell Breed Senior Professor in Design and codirector of the Segal Design Institute. "It's about understanding users and stakeholders, and how—through design and technology—you can impact lives and solve problems."

The problems these students are asked to solve are not trivial. In 2003 McCormick began a collaboration with the Rehabilitation Institute of Chicago. Under the direction of Elliot Roth, the Paul B. Magnuson Professor and chair of physical medicine and rehabilitation in the Feinberg School of Medicine, RIC had received a grant from the US National Institute on Disability and Rehabilitation Research enabling it to partner with engineering students to design solutions for their patients.

"It's been a tremendous experience," Roth says. "We've been able to teach engineering students the importance of working with people with disabilities to improve their functionality. The students learn the importance of listening to clients, and they create products that have immediate impact. Together we've been able to create some great devices."

"It was a way to get students involved with people with disabilities," Ankenman says, "and it was a way to introduce them to technically uncomplicated projects. They participated in user observations and feedback that was critical to what we teach at Segal: that students need to design products that make the user happy and comfortable."

Products that make a difference

Now, most McCormick students work on RIC projects in their first quarter of EDC. For many, it's their first foray into product development, a process that involves its share of hits and misses—as the team charged with designing a jar-opening device learned.

"We had things that attached to a table with a clamp and screw, and then attached to a jar with a clamp and screw, and you pushed one around," remembers team member Doug Peterson (industrial engineering '11). "It was complicated."

Another idea was a wedge that fit under a kitchen cabinet. A third idea involved a plunger. "Mechanically, that turned out to be a nightmare," Stein says.

"One idea had the jar upside down before we realized that when you got it open, all of the contents would fall out," Peterson says.

Left: The Ford Motor Company Engineering Design Center. Right: Students consider designs with Segal Design Institute faculty members Charles Yarnoff and Bruce Ankenman. *Photos by Andrew Campbell.*

Photo by Gregory Snyder

Encouraging innovation

McCormick is not alone in its push for entrepreneurship. The Innovation and New Ventures Office (formerly known as the Technology Transfer Program) guides professors through intellectual property and licensing issues. The office is headed by Alicia Löffler, associate vice president of research, who has a background as a faculty member at the Kellogg School and in the biotech field.

"Our goal is to inspire innovation and create a bridge between Northwestern's research and public benefit," Löffler says. "We are working across the University with both professors and students to create a new culture of innovation. McCormick is also working toward this goal, and we're excited to have it as a great partner."

Given McCormick's emphasis on entrepreneurship and innovation, it is no surprise that it plays a significant role in the activities of INVO. From July to December 2010, INVO helped McCormick faculty—guiding them through intellectual property and licensing issues—with 55 new inventions. That's more than half of all the projects overseen by the office during that time. INVO also helped McCormick faculty found five new start-ups in 2010—more than any other school at the University.

In addition to overseeing individual faculty projects, INVO works closely with the Farley Center: Farley Center director Mike Marasco sits on the INVO board, and the NUvention: Energy course draws on INVO's expertise to determine which green technologies developed at Northwestern might be viable businesses. "The Farley Center is better positioned today because of INVO," Marasco says.

Finally they came up with a utensil with two conical indents into which users could place different-sized jars while they opened the top with one hand. The students soon realized that one cone-shaped indent was enough, and they created a prototype that looked like a volcano. The "Jarcano" was born.

They built a prototype out of wood, but needed a material that prevented the jar from slipping once inside the cone. They found Dycem, a high-friction rubber, but even that proved troublesome: it wouldn't stick with glue, it became useless when wet, it fell apart in layers when they tried to cut it. Eventually, they succeeding in making a prototype (using staples and cutting the Dycem with a laser) and brought it to RIC for testing.

They didn't even need to show the patient how to use it. He set it on the table and immediately opened a jar. "He got wedded to it right away," Peterson says. "We told him we had a different prototype for him to try, and he said no."

"He had this look on his face," says team member Jonathan Stockton (mechanical engineering '11). "He just stared and pointed."

As they developed the Jarcano, the team worked with Edna Babbitt, a therapist at RIC who introduced them to the patients who would test their designs. "They presented themselves professionally," she says. "They took it very seriously. I thought their final design was great. It seemed like it could be functional for everyone from stroke survivors and amputees to people with arthritis. It's something I'd like in my kitchen."

As EDC found success with RIC projects, McCormick wanted to expand the undergraduate curriculum to include design courses beyond the freshman year. Today the school offers courses on industrial design, computer-aided design and intellectual property as well as those involving interdisciplinary design projects. "We have a nice suite of courses at the undergraduate level," Ankenman says. "They provide opportunities for design and give students the tools to make better design projects."

Students have brought design into their extracurricular activities, as well. The Design for America student group uses design for social good and has received accolades for its work on improving hand hygiene and reducing water consumption. Other student groups, including Engineers for a Sustainable World and Global Architecture Brigades, have designed projects for communities in developing countries. "There are a huge number of students who are very excited to design for local and international social impact," Ankenman says. "They haven't even graduated, and already they want to use their design skills to make a difference."

To further extend its commitment to design, McCormick has also created a master's program in engineering design and innovation (MS-EDI). "We wanted a cohort of graduate students who were committed to design and could be here full-time to flesh out our design culture," says Colgate, who directs the program. The 15-month curriculum, which includes a summer internship, is largely project based. Students have worked with companies locally and nationally to design products ranging from a solar-powered rechargeable battery to a new type of bottle cap.

"We want to promote design across the University," he says. "Design—understanding problems, creating solutions—is what drives innovation in society, and we hope to cultivate that way of thinking so our graduates can be successful in this global economy."

Creating innovation for industry

McCormick has also expanded its design education to meet industry needs. Six years ago the MMM program—which combines the master's in engineering management with a master of business administration degree—began to include courses on product design and development. Don Norman, a well-known figure in the design field, joined as codirector shortly thereafter. His design thinking, coupled with the systems expertise of Sudhakar Deshmukh, the Morrison Professor of Managerial Economics and Decision Sciences in the Kellogg School and MMM codirector, led the program to be refocused on design and operations. More recently, another graduate program, focusing on product development for midcareer designers and featuring both business and design courses, was renamed the Master of Product Design and Development (MPD^2) program to highlight the role of design in the curriculum.

In 2010 both the MMM and MPD^2 programs got a new codirector in Greg Holderfield, who was

Jonathan Stockton, Ted Stein, and Doug Peterson work on prototypes for the Jarcano, a jar-opening device. *Photo by Andrew Campbell.*

previously vice president of design and strategy at ARC Worldwide–Leo Burnett. Holderfield, an MPD[2] alumnus whose design work has been recognized globally with more than 25 industry awards, said he returned to help influence the next generation of designers.

"I sought out the program as a student because I knew the industry need was shifting into strategic thinking," he says. "I wanted the skill sets that would allow me to hold my own at the table of business. When I graduated, I felt significantly empowered because I had a set of tools that enabled me to succeed and branch out in my career. I saw returning as a director as a great opportunity to help other students find the way."

Holderfield's approach to teaching builds off his successful 20-year career in industry; he is tuned into the needs of consumers, organizations, and students. In his graduate courses he pushes students to be creative through what he calls "process-plus-possibility-based thinking," which, he says, fosters interdisciplinary development and in turn produces meaningful innovation.

"It's a truly collaborative way of problem solving that considers all aspects of the innovation process," he says. "My undergraduate education in industrial design took place in a school of fine art, which I always believed shortchanged the perception and role of design in innovation. Teaching process-plus-possibility-based thinking provides a unique skill set in a school of engineering that elevates the traditional practice of design beyond object-based development. It's about creating real meaning. It took me 15 years and a master's degree to cement that idea; students today don't have that time."

> "Our students learn not only how to solve problems but also how to frame them."
>
> J. EDWARD COLGATE

One of the ways Holderfield and Colgate hope to push design at Segal is to recruit PhD students to facilitate more design research. Elizabeth Gerber, assistant professor of mechanical engineering, was hired two years ago to begin that process. Her own research looks at how people innovate individually and in teams.

"We need PhD students to elevate design at the University," Holderfield says. "We want to bring in graduate students who can study this process and help support this thinking. Northwestern has the great fortune to be a leader in engineering, and design has endless opportunities for growth. The industry is extremely interested in what's going on here. "

From the classroom to the community

The Jarcano has continued to evolve over the past two years. Several more students refined the design, changed the materials, and fabricated 10 new versions for RIC to give out to those who need them. Segal administrators would like to create many more using mass-manufacturing techniques, but that's not realistic. "We can't make thousands of the products we develop," Ankenman says.

To get around this stumbling block, McCormick has partnered with University of Illinois at Chicago's RecTech program, a clearinghouse for information on recreational opportunities for people with disabilities. McCormick students can post their RIC-related innovations on the RecTech website with assembly instructions (wiki.rectech.org). "That way users can build one of our devices or find someone to build it for them," Ankenman says. "It's an outlet for us to bring our designs to the public."

The idea that their designs can become products that are really used by people is a major motivator for McCormick students. "It's discouraging when you work on something for hours and hours, and then it ends up in a file cabinet," says Peterson. "The greatest success of a project is when it's used after the project is over."

That real-world application is precisely what the Segal Design Institute aims to achieve. "Design is what engineers do to make a difference in the world. It's what has solved many problems of humanity," Ankenman says. "Design is continually evolving. We hope that our curriculum and research continue to evolve along with it."

M Emily Ayshford

BETTER BRIDGES

McCORMICK'S INFRASTRUCTURE TECHNOLOGY INSTITUTE HELPS THE CTA MONITOR THE STRUCTURAL HEALTH OF ITS BRIDGES

Under the 100-year-old "L" tracks that cross over Devon Avenue in Chicago, a little silver box is hard at work. As hundreds of Red and Purple Line trains rumble overhead each day, the box collects measurements from an array of sensors on the viaduct. They measure the strain on the bridge's retrofitted shoring—the steel supports installed more than a year ago to help deteriorating concrete columns carry the load. Each day the box uploads the data to a secure project website at the Infrastructure Technology Institute, and from there engineers from the institute and the Chicago Transit Authority can monitor the structural health of the bridge.

The project is a perfect example of the sort of work ITI was created to carry out. The institute, supported by a grant from the US Department of Transportation, employs a team of research engineers and faculty members to develop strategies and tools to protect and improve the condition, capacity, and performance of the nation's highway, railroad, and mass-transit systems. State-of-the-art technology like that used at the Devon Avenue bridge helps the CTA determine which bridges need to be replaced and when. It also provides huge data sets on long-term bridge health that will help engineers everywhere make better choices about which ones to replace or repair.

The project began when CTA president Richard L. Rodriguez saw an ITI newsletter and arranged a meeting to ask how the two organizations might work together. The partnership seemed a perfect match: The CTA has hundreds of century-old bridges that need monitoring. ITI engineers have years of experience installing sensors to monitor bridges around the country remotely, providing data to help make decisions about structural integrity.

"Over its 18-year history, ITI has deployed remote sensing systems at more than 80 sites around the country," says Joseph Schofer, director of ITI as well as associate dean for faculty affairs and professor of civil and environmental engineering at McCormick. "We're equally pleased to contribute something of value to our hometown transit system."

"I don't know of anybody else who has continuously monitored bridge data over that span of years and years," says Dan Marron, ITI's chief research engineer. The engineers work as a team, from planning and installation to data analysis, and have made some critical discoveries. For instance, they were able to alert one state's department of transportation when their sensors detected a crack in the main gear of the drivetrain of a drawbridge.

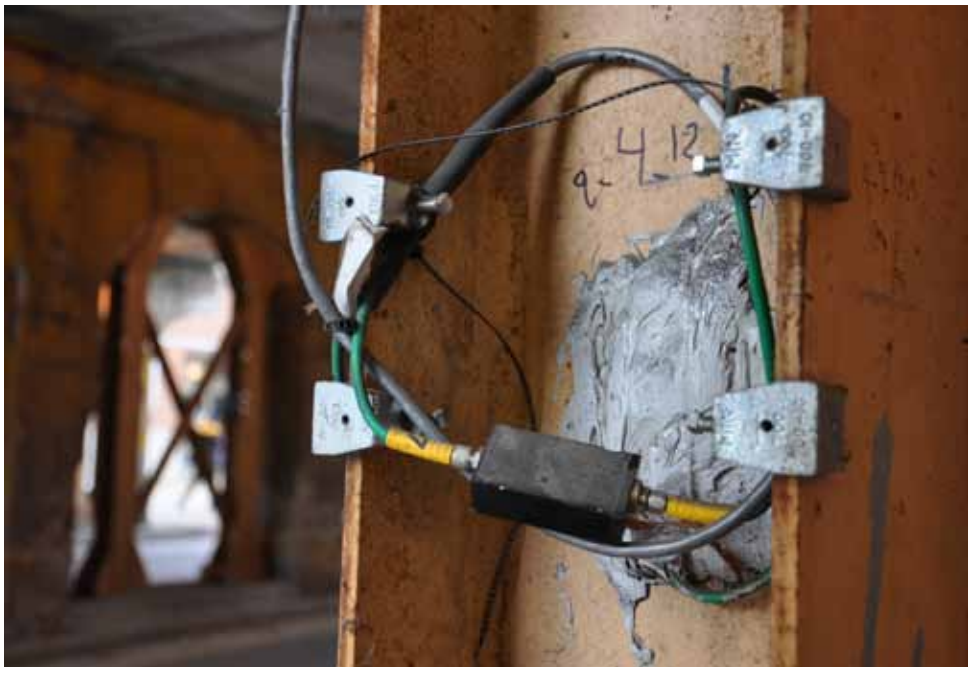
In late 2009, as the CTA installed the steel shoring under the Devon Avenue bridge, ITI engineers installed 10 vibrating-wire string gauges in the shoring's concrete pads to measure long-term loading. When the bridge load starts to transfer from the concrete columns to the shoring, the sensors pick it up. A few months later the engineers added seven resistive-strain gauges that measure how much the steel beams stretch or compress each time a train passes. The tiny sensors—each an inch or two square—were spot-welded to the steel columns and wired to the data logger in the silver box. A computer processes the signals from the sensors, filters out the noise, and stores the signals until their daily transmission to the ITI servers at Northwestern. There they immediately become part of the project's website, displayed as easy-to-read graphs that show the load for each train that crosses the bridge.

"We're doing a load test every 10 minutes every day for a year," says ITI research engineer David Kosnik. "We're seeing real-world response rather than one from a computer model."

ITI's monitoring shows that the steel shoring, which is 7½ feet tall, compresses about 305-millionths of an inch per train—a tenth of the diameter of a human hair. "That means the original bridge is carrying most of the load." Marron says. "If we used the sensors available five years ago, we wouldn't be able to detect strain this small."

"The device that Northwestern developed is a valuable tool that supplements our own

Left: Dan Marron and David Corr of the Infrastructure Technology Institute. *Photos by Emily Ayshford.*



inspection of the aging concrete bridges along the Red and Purple Lines," says CTA President Richard L. Rodriguez. "By virtue of their conservative design, the bridges have withstood time and the elements. Until these bridges can be replaced, CTA has erected shoring, and Northwestern's device supplies another layer of data for our analysis when determining if adjustments need to be made. The device at Devon has shown that the shoring is installed properly and provides a rigid path between the bridge deck and the foundation."

David Corr, clinical associate professor of civil engineering and an ITI research engineer, is working with Pablo Durango Cohen, associate professor of civil and environmental engineering, to analyze the sensor data and determine the overall health of bridges, taking into account the different materials (steel, concrete, etc.) that make up the structures. Durango Cohen has created statistical methods to determine the condition of pavement, and he and Corr are creating methods to determine the condition of more complex structures like bridges. "We don't just collect the data," Corr says. "We use it to develop quantitative tools that can help make decisions about what needs replacing and repairing."

The CTA project also serves as a way to get undergraduates excited about civil engineering. Students have helped ITI engineers on nearly every aspect of the project, including creating CAD drawings, building and testing the sensor systems, installing them on the bridge, and examining the data streams.

"This partnership benefits everyone," Schofer says. "The CTA gets high-quality, real-time data to assess the integrity of its infrastructure. Our research engineers and faculty get a unique data stream of research. And students get hands-on experience with civil infrastructure systems."

Since the bridge is just three miles from the Northwestern campus, the ITI team would like to make it a platform for trying out new bridge-sensing technologies such as acoustic testing, whereby engineers locate the source of a crack or defect by detecting sounds within the concrete. "We'd like to figure out if there is a simpler way—perhaps using only one or two strain gauges—to implement a system like this on more CTA bridges around the city," Marron says.

Ultimately, the project exemplifies what the Infrastructure Technology Institute aims to do: use remote structural-health monitoring to better manage public infrastructure. "Everybody knows there's not enough money to replace every aging bridge," Marron says. "Using sensors like these is another tool that allows you to make better choices about which ones to replace or repair." **M** Emily Ayshford

ENERGIZING RESEARCH

Are new materials the key to sustainability?

IN THE SEARCH FOR NEW SUSTAINABLE ENERGY TECHNOLOGIES, ANSWERS OFTEN LIE NOT IN DEVICES BUT IN THE MATERIALS THAT MAKE THEM WORK. IN EVERYTHING FROM PHOTOVOLTAIC CELLS TO FUEL CELLS AND ELECTRODES IN BATTERIES, RESEARCHERS ARE LOOKING AT MATERIALS—HOW THEY ACT UNDER DIFFERENT CIRCUMSTANCES, AND HOW THEY CAN BE DESIGNED—TO FIND NEXT-GENERATION SOLUTIONS TO OUR GROWING ENERGY PROBLEMS.

Left: Scott Barnett holds up a fuel cell. Right: Barnett works with graduate student Scott Cronin in his lab. *Photos by Andrew Campbell.*

Faculty in McCormick's Department of Materials Science and Engineering have been focusing on the problem of sustainable energy for decades. As funding for energy research increases, McCormick efforts in the area have grown dramatically. Now 49 percent of the department's research expenditures involve energy research, with projects covering everything from theory to experimentation to characterization. Mark Hersam, Scott Barnett, and Chris Wolverton—all professors of materials science and engineering—are among the many leaders in the search for the materials that will drive new energy technologies.

PUTTING FUEL CELLS INTO REVERSE

To create electricity, many power plants take a fossil fuel, burn it to create heat, and use that heat to run an engine that drives a turbine that finally creates electrical energy. It's a long process that results in an efficiency rate of only about 30 percent.

Scott Barnett, professor of materials science and engineering sees a better way: fuel cells. For 20 years Barnett has researched fuel-cell technology to improve the production of electricity. Fuel cells use an electrochemical reaction to produce electricity directly from the fuel and work by exploiting the reaction between oxygen and hydrogen. By combining hydrogen from a fossil fuel directly with oxygen, it is possible to harness the electricity from the reaction with an efficiency of 40 to 60 percent, nearly twice the efficiency of conventional power plants. Fuel cells also have a much lower rate of carbon dioxide emission.

"The technology has come a long way," Barnett says. "Fossil fuels like coal are going to be in use for a long time to come, until renewable energy sources take over, and fuel cells provide a means for using them more efficiently and reducing our production of CO_2."

So why aren't fuel cells used more often? NASA has used them on its space shuttles, and Google uses fuel cells to power part of its private headquarters. But the cells are still relatively expensive, and most can't yet be used directly with fossil fuels. Little is known about their durability or lifespan or whether their cost can be reduced enough for broad commercial markets.

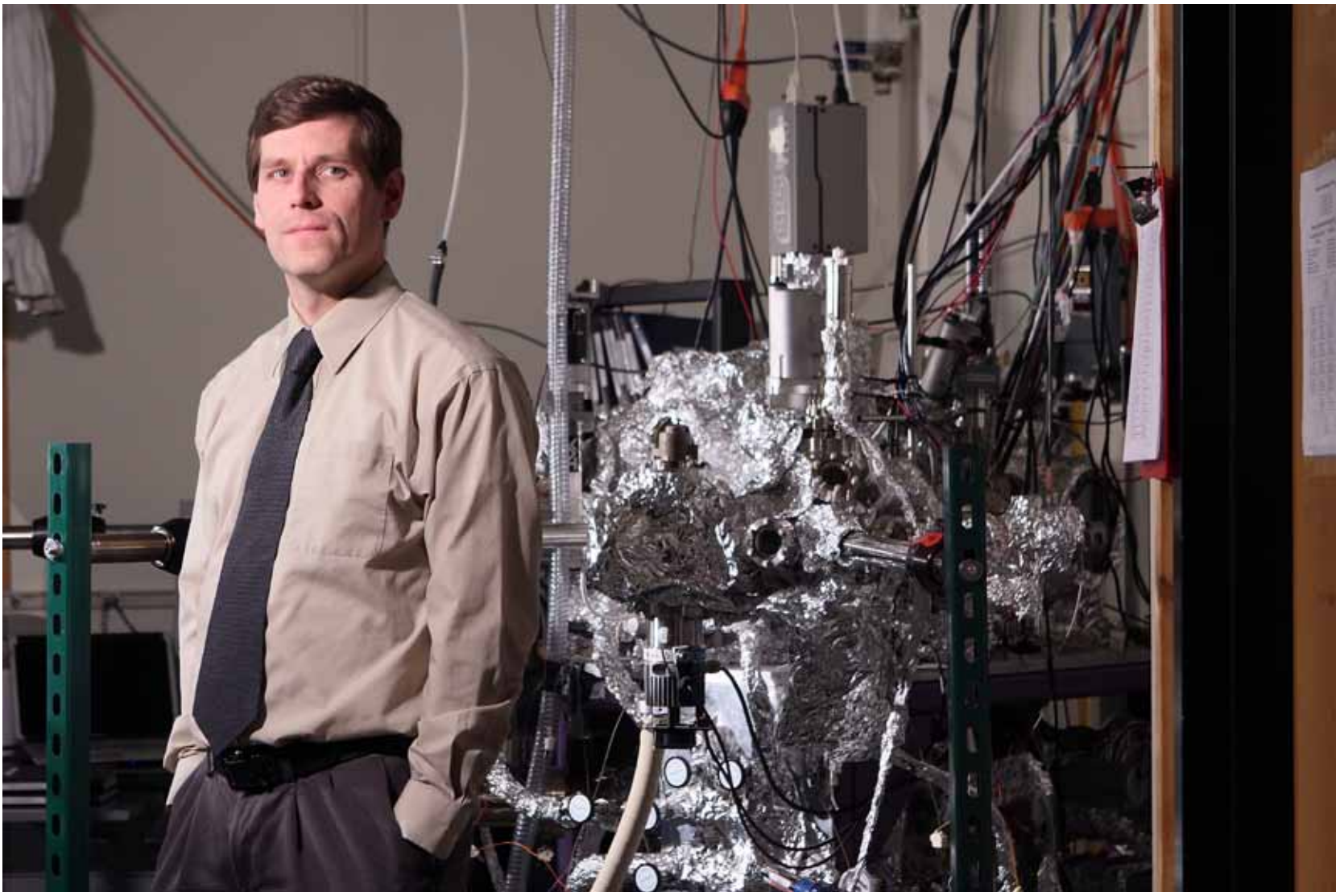
Barnett's work has focused on answering some of those questions by better understanding how a fuel cell works, engineering better materials to improve efficiency, and even using fuel-cell technology for new application, such as energy storage.

Over the last five years Barnett and his research group have been using special microscopy techniques to peer inside fuel cells to see just how they work. Barnett's team, working with Peter Voorhees, the Frank C. Engelhart Professor of Materials Science and Engineering, spent several years trying to figure out the process for imaging the fuel cells—no one had ever done it before. The process they have settled on works like an MRI: a microscope produces 3-D images that show the inside of a fuel cell, revealing its electrochemical processes.

"Being able to accurately measure these structures is useful in figuring out how they actually work," Barnett says. "We're trying to get a handle on how fuel cells degrade over time, and we can do that with this technique. That will allow manufacturers to make better fuel cells in the future."

More recently, Barnett's group has explored ways to use fuel cells for energy storage. As people use more and more renewables in the energy grid, one of the big issues is that these sources are intermittent in nature. For instance, solar energy is produced during the day, which doesn't match consumption patterns. "You have to have some way of storing the electricity," Barnett says.

In order to use fuel cells for energy storage, Barnett is finding ways to



run them in reverse. The idea is that the fuel cells would take in electricity, along with CO_2 and water, then convert it to methane, which could then be stored with the natural gas supply. Since natural gas is easy to store, it can be accessed when energy is needed. "We've done a lot of the background calculations to show that it has the characteristics you need for a good energy-storage system. People worry about cost, availability of materials, efficiency, and long-term durability," Barnett says. "We have predictions that look good but have to be fleshed out in practice."

UNDERSTANDING BATTERIES

One of Mark Hersam's earliest engineering courses as an undergraduate focused on energy. That class sparked an interest that led him to undergraduate research projects working with a professor whose specialty was nuclear engineering. At the time, however, funding for energy-related projects was hard to find. "It was obvious there wasn't a lot of funding and that it would be difficult to do work in this area," Hersam says. "I tabled that idea and began working on electronic materials. But I kept my interest in energy research."

Now Hersam's early interests in energy are well suited for a new funding environment. Nearly 40 percent of the current research in his lab is related to energy, up from just 5 percent three years ago. "Energy research has really come onto the scene," he says.

In 2008 Hersam and his group developed a technique called atomic-force photovoltaic microscopy that measures the electrical current of photovoltaic materials using a tiny conductive tip that is just 10 nanometers in diameter. "Using this technique we can see which parts of the solar cell are running at full capacity," he says. "We can determine what parts are inefficient, diagnose the sources of the inefficiency, and, from that knowledge, deduce what the problem is and refine the materials for future use."

Hersam is trying to gain a similar understanding of the material structures and chemical reactions that occur within batteries. In particular, he is focusing on the interface between the electrode and the electrolyte solution inside the battery, known as the solid electrolyte interface, or SEI. "The SEI region is poorly understood but widely believed to be critical to the operation of the battery," he says.

Understanding the function of the battery has important safety implications: there have been several high-profile incidents of lithium ion batteries catching fire or even exploding. As these types of batteries are used in a wide variety of applications—including powering electric vehicles—it is critical to understand and predict the reactions that take place within the batteries.

Studying the SEI is a challenge. Microscopy techniques are typically conducted in pristine conditions inside ultrahigh-vacuum chambers. To study the battery, however, Hersam and his team must examine the interface while it is submerged in a highly corrosive, flammable electrolyte solution.

Left: Mark Hersam. *Photo by Andrew Campbell.*
Above: Graduate student Albert Lipson uses the glove box to conduct research on solid electrolyte interfaces. *Photo by Andrew Campbell.*
Right: Chris Wolverton. *Photo by Sally Ryan.*

"Typically we don't even want air to touch what we're analyzing, let alone a corrosive material," he says. "Moving into a complicated, corrosive electrochemical environment isn't trivial. But it's an important challenge for microscopy to operate in real environments, especially where energy processes occur."

Hersam and his team have adapted their equipment to handle the corrosive electrolyte solution. They conduct experiments in a glovebox, allowing atmospheric control of the sample. These techniques allow them to open up the battery and measure the currents at the SEI.

"Within the battery we can see 'hot spots' where the chemistry is happening quickly and perhaps uncontrollably," he says. "We can pinpoint and diagnose failure points. That understanding gives us a fighting chance to engineer a solution to those problems."

SCREENING MATERIALS FOR SOLAR ENERGY

While many faculty members have added energy-related research to their portfolios as a result of increased research funding, Chris Wolverton has long devoted all of his research to materials with applications in energy—research that is entirely theoretical and computational.

"The kind of calculations we can do are on the atomic scale and based on quantum mechanics," he says. "They're interesting because, while we've known the equations that govern the motion of electrons and solids for some time, we are now realizing the ability to use them to our advantage."

Wolverton, a professor of materials science and engineering who joined McCormick four years ago after working for Ford Motor Company, uses a combination of improved algorithms and newly available computational power to develop highly realistic simulations of how different materials behave. Those simulations allow his team to screen hundreds or thousands of materials based on the characteristics required for a particular application and even extend to materials that don't yet exist. Such capabilities can, in collaboration with experimental efforts, accelerate the development of new energy technologies.

One recent project is in the area of solar energy—with a unique approach. "Most people use solar radiation to produce electricity," he says.

> "A lot of energy problems come down to the fact that we don't have the materials we'd like to have."
>
> CHRIS WOLVERTON

"We're working with a group from Sandia National Laboratories to use heat from solar energy to drive a reaction that could turn water and carbon dioxide into syngas."

Syngas is a key ingredient in the industrial production of fuels such as synthetic natural gas, synthetic petroleum, and methanol. Synthetic fuel derived from "recycled" atmospheric carbon dioxide with this solar thermal technology is carbon neutral and therefore does not exacerbate global warming as conventional fossil fuels do.

Colleagues at Sandia have developed a process that works by focusing solar energy to heat a reaction chamber to extremely high temperatures. Within the chamber, a wheel made of a type of metal oxide rotates as it is heated and cooled. While the material is exposed to the heat, it vents oxygen and transforms into a reduced form. Back in a cooler environment, that reduced form of the material wants that lost oxygen back and will split other molecules apart to get it. Exposing it to water results in the creation of hydrogen, and exposing it to carbon dioxide results in carbon monoxide; combined, the system provides the necessary components for syngas.

The project is part of Sandia National Laboratories' "Sunshine to Petrol" project, which is a major initiative at the lab. Sandia has already demonstrated the feasibility of the technology, but the efficiency is still lower than needed to be commercially viable. Once optimized, such a system could provide an ideal renewable resource to create synthetic fuels, the combustion of which would contribute no new CO_2 to the atmosphere.

Wolverton and his group are working to define the ideal thermodynamic properties needed for this process and are screening a wide variety of materials to attempt to find an optimal material for the process—a situation that's common to many sustainable technologies. "A lot of energy problems come down to the fact we don't have the materials that we'd like to have," he says. "That's not a peripheral problem. That's a key problem. The worldwide challenge is to find new materials that enable solutions to these problems."

M Kyle Delaney

Mobile menagerie

Students partner with the Lincoln Park Zoo to create a mobile app

There are the lions. The giraffes. The seals. More than 1,200 animals on 35 acres at the Lincoln Park Zoo in Chicago. Where do you start? What shouldn't you miss? When are they eating? Where can you eat?

As the saying goes: *There's an app for that.*

Team members Matthew Gilk and Vijay Shankar use the app at the Lincoln Park Zoo with adviser David Nichols. *Photos by Andrew Campbell.*

A recently developed Lincoln Park Zoo application provides maps, photos, schedules, and animal information for curious zoo visitors. It's the result of a multidisciplinary project that allowed Northwestern students to apply what they've learned about computer science, management, and marketing to create a real business and work with one of Chicago's oldest nonprofit institutions.

The project started in a spring 2010 NUvention: Web course, where students design, build, and run software-based businesses in multidisciplinary teams. A mix of graduate and undergraduate students from the McCormick School, the Kellogg School of Management, and the Judd A. and Marjorie Weinberg College of Arts and Sciences set out to design an application for a specialty rugged outdoors cell phone. But the team members soon realized they wanted to create an application for a wider audience, though they liked the idea of an app for an outdoor venue. "Many places that don't have official tours could benefit from the dynamic tour you create in a mobile app," says Kelsey Recht (Kellogg '10).

As a dry run, the team mocked up a tour of Northwestern's campus, complete with audio streaming, photos, and information. The initial feedback to this app from the course's advisory board was positive, so the team began researching markets. They considered outdoor venues where a map would be helpful and where traditional museum tour headsets cannot be used. The team connected with David Nichols ('91, Kellogg '00), a member of the McCormick Advisory Council and the Lincoln Park Zoo board, who had been advocating for more use of social media at the zoo. "But because the zoo is free, we don't have a large revenue stream to create a program like this ourselves," Nichols says. "The zoo is one of the few attractions in Chicago that has live exhibits, so it's suited to a mobile application."

The team formed a company called Enthusiast Apps that would offer clients like the zoo yearly paid subscriptions for specialized mobile tour apps. In addition to the tour, clients receive reports showing where visitors go and how long they spend at the zoo.

Matthew Gilk (computer science '12) was charged with creating the application for the iPhone. There was only one problem: he'd never created an iPhone app before. "I was completely ignorant as to how you set up a system like this," he says. "The difficulty is the organization of data and how you grab that data from our servers. But just like in the real world, you have deadlines that you need to meet. You have to get something on the market."

Gilk became deft at searching online forums and technical guides for help, and by the end of the course he had thrown together an app. "It was buggy, and it was pretty ugly, but it worked," he says. As the zoo reviewed his work and began to ask for more features, it became clear that Gilk would have to take the summer to rebuild the app entirely. He had a full-time job but spent his nights and weekends coding. "At this point I had put so much work into it that I really wanted to succeed," he says. "But it was the worst summer of my life. I was pulling all-nighters. Ultimately I reached a new plateau of understanding how apps work, and I'm really grateful for the experience."

The group created a test app for Zoo Lights, the zoo's holiday lights festival. That, too, was tense for Gilk—the initial app he sent to the iPhone store was rejected. A few minor adjustments and a personal plea got it online in time for the show, and ultimately, hundreds of users downloaded the app.

The rest of the winter the team focused on fine-tuning the app. It currently has more than 150 destinations on a map of the zoo, complete with video, audio, and photos. For example, if you walk by the lions' den, information on the animals automatically pops up on your phone. The app provides information on scheduled feedings and will ultimately include real-time updates about what the animals are up to.

"It has been very engaging," says Marybeth Johnson, vice president of communication and public affairs for the zoo. "We hope it will enhance the visitor experience at the zoo."

The team hopes to officially launch the application in April. Look for it under LPZoo in the iTunes store.

"It has been a true collaboration," Nichols says. "It's going to provide a fantastic experience for people who come to the zoo, and it's given these students an opportunity to create a business. I'm proud of what they have done. It's truly a professional, top-notch application."

Enthusiast Apps hopes to use its experience with the zoo to attract more clients. None of this would have been possible without NUvention: Web, they say.

"In many ways the course simulates how the actual work environment at a start-up might be," Recht says. "You have technology people who are phenomenal coders, and you have business people who know nothing about technology but have a business and marketing background. That sort of collaboration is a valuable experience for everybody." M Emily Ayshford

Top: Mehri Paydar works on her design at the desk of architect Helmut Jahn. Bottom: Sketches of proposed events at the Sony Center in Berlin. *Photos by Gordon Welters.*

Architecture in Berlin

Undergraduates work with Helmut Jahn

At 10 a.m. on that Thursday morning in Berlin, the office was silent. Eight students—all part of McCormick's Architectural Engineering and Design Program—hunched over their desks, hustling to finish the projects they'd been working on all week. Their charge: design an event that would take place in the atrium of the Sony Center, a multibuilding complex in the center of Berlin that has become a symbol of the city's ongoing redevelopment. Their guide: Sony Center architect Helmut Jahn, who has designed dozens of buildings around the globe and whose Berlin office the students had taken over for the week.

Preparing to present their designs to a jury, the students drew and erased and drew again, gluing together tiny models made of fabric, felt, leaves, and cardboard. "I hope they like it," said Francesca Ferrero (civil engineering '11), who designed a pop concert for the venue. "Actually, I hope *I* like it."

"It's coming along," said Matthew Shaxted (civil engineering '11), who ditched his model in favor of simple drawings. "Well, it's a little difficult. I didn't sleep."

In just a few hours, the students would hang up their sketches and try to sell their ideas to a jury most architecture and engineering students could only dream of: Jahn; Laurence Booth, who, in addition to being director of the renowned Chicago architectural firm Booth Hansen, is the Richard C. Halpern/RISE International Distinguished Architect in Residence at McCormick and director of the Architectural Engineering and Design Program; Steffen Duemler, principal architect in the firm of Murphy/Jahn; Leif Selkregg, CEO of the project management company RISE International; and renowned structural engineer Werner Sobek, who with Jahn designed the Sony Center and coined the term "archineering" to describe the combination of architecture and engineering that ultimately creates better buildings.

Finally, it was time for the students to present. Ryan Shanahan (civil engineering '11) stood next to his drawings. The room was quiet—this time, in anticipation.

Shanahan began: "When we walked into the Sony Center, I immediately felt like I was in a coliseum."

And the jury listened.

A blended approach to architecture

The Architectural Engineering and Design Program began in fall 2008 after Dean Julio M. Ottino saw an opportunity to combine Chicago's architectural strengths with the design initiatives at McCormick. "Given the city's prominence in architecture," he said, "I felt it was important that Northwestern be part of that world."

At the same time Selkregg and Richard Halpern, cofounders of Chicago-based RISE International, began discussing how architecture could be integrated into McCormick's curriculum. RISE often hires McCormick students for co-op programs and jobs after graduation, and Halpern is a member of the McCormick Advisory Council. "The most important buildings have this blended approach to architecture and engineering," Selkregg said. "We thought engineering students would benefit from an architecture education."

The pair made a generous donation to endow the architect-in-residence position now held by Booth. "I find it exciting to use my experience and pass it on to others," said Booth. "I want to make architecture as interesting for them as it has been for me."

The Architectural Engineering and Design Program consists of three studio courses in which students create progressively bigger projects. In 2009–10 students first designed a coffeehouse, then a school, then a skyscraper. They also learned how to use energy-modeling software to make their buildings more sustainable. Ultimately the program offers students a new perspective

on engineering: Beyond the physics and math behind materials and systems, how can those elements come together into something that is both efficient and aesthetically pleasing? How can students use both analysis and creativity to design something great?

Once the program was into its second year, those involved began discussing how to bring students into a professional architecture environment. "We envisioned the program as both practical and international," Selkregg said. "Creating these workshops and real-life experiences was the fundamental thinking behind the program. We had a relationship with Helmut Jahn and his office, and he was generous enough to agree to be our first host."

Studying architecture in Berlin

Eight students in the program spent a week early last September at the Berlin offices of Murphy/Jahn working on a design project and observing the workings of an architecture firm.

"Berlin is kind of a microcosm of Europe as a whole," said Corey Bertelsen (civil engineering and music '11). "You had the communist-capitalist conflicts and all the damage from World War II, but there is also an incredible rebuilding effort. The most striking thing was how mixed the buildings are—bombed buildings mixed with old refurbished buildings and really new modern buildings."

The assignment was to design an event for the central forum of the Sony Center, a nine-building complex on Potsdamer Platz that includes offices, stores, restaurants, apartments, and a movie theater.

Ryan Shanahan—who thought the forum, with its airy oval roof, resembled a coliseum—decided his event would be the opening ceremonies for the Olympic games. But it soon became clear the space just wasn't big enough. A better event, he reasoned, would be a festival space for watching the Olympics on giant television screens. Jahn demurred. "I told them on Monday morning: get one idea and don't change it," he later said. "If you come up with another idea, you'll still have the same problems."

The projects were as diverse as the students: a fashion show, a pop concert, a biology exhibit, an acrobatic act, a ballet performance, and a giant turbine propelled by the body heat of spectators.

That last idea belonged to Matt Shaxted, who had trouble explaining the abstract concept that stretched the definition of an event: "I wanted to create a turbine installed on the Sony Center's spire and use it to create electricity through the use of environmental temperature. The more people you have in the space, the more the temperature will increase, and the temperature differential will cause the turbine to work."

On Tuesday afternoon Shaxted and the rest of the students had their first review with Jahn, who is known for offering honest, unrestrained feedback. "The critiques were rough," Shaxted said. "Everybody was pretty nervous. I went up there and put up my 10 different sheets of ripped paper, and Helmut said, 'What is this? You need to make it clean and professional. Keep that with you your whole life.' He was right."

On Wednesday morning the office was silent. Students sketched and drew and considered their designs. Shaxted sat down with Jahn and explained his concept at that point. The turbine could generate electricity, he said, which could be used to power something else, like cars.

Jahn shook his head. "You just have to keep some kind of reality," he said. "The temperature differential—that's not enough to drive it."

Shaxted nodded. "You're right. I don't know."

By the end of the day Booth had arrived, encouraging the students whom he had mentored all year.

Referring to her pop concert design, Ferrero said, "I made a telescoping catwalk that would be hidden under the stage. The artist could sit on top and be telescoped out, and the stage would be covered in reflective fabric, so the lights that shine off the disco ball will reflect in the Sony Center."

"Keep drawing," Booth said. "It looks great."

Students stayed late at the office that night and arrived early the next morning to finish their designs. "There's no sleep in architecture," said Jeff Gellis (civil engineering '10) as he glued tiny leaves onto his model, a mountain-themed amphitheater with rock walls and performance space.

Finally, it was time for the final jury. Jahn gathered the students in his office. "What's important is to clearly state what you wanted to do and how you dealt with the space," he said. "That's what architecture is all about. You've got a problem, and so you design a solution."

When the jury was assembled and the drawings were posted, students waited for their turn to stand before the five architects, engineers, and businessmen who have had a hand in designing

WATCH A VIDEO ABOUT THE BERLIN TRIP AT MAGAZINE.MCCORMICK.NORTHWESTERN.EDU.

Top left: Jeff Gellis glues together a model of an amphitheater.
Lower left: Matt Shaxted presents to the jury in the Sony Center.
Left: Helmut Jahn discusses the design challenge with Northwestern students.
Photos by Gordon Welters.

and building some of the best structures of the past 30 years.

"I hope you had a good time this far," Jahn said, smiling. "I hope you survived this."

Selling your design

What happened next was more than a design critique: it turned into a wide-ranging conversation on design, business, communication, and the difference between art and science.

When Shaxted presented his turbine idea, Sobek told him it would require a building much larger than the Sony Center.

"Sometimes you get attached to an idea," Booth told Shaxted. "We all do. You get so caught up."

Jahn pointed out that Shaxted only had one drawing to show the jury, a sketch of the turbine and the mathematical equations he thought would show it worked. "If you're trying to sell something to a client, he never takes the first thing you show him," Jahn said. "The process is very important. If you come with one drawing, the client will think you didn't take it seriously."

"You always must be aware that there might be a specialist in the jury who is not shocked by the math," Sobek said, pointing to Shaxted's equations. He added that architects should always be able to clearly articulate their ideas. "You should train yourself to close your eyes, pick up a virtual phone, tell somebody how it works, and sell it to them. Sooner or later you'll realize that you need the right key words or story."

When Lizzie DuBay (civil engineering '11) presented her fashion show idea, Jahn asked why she drew her designs by hand.

"It gives it more personality," she said.

"So you can throw your computer away when you get back!" said Jahn, who is known for designing buildings using freehand drawings. "The computer is the worst equalizer. It makes it possible for people who are not very good to do well. It's like putting fancy clothes on."

Sobek added: "On a flight from Frankfurt to Chicago I drew all of the special structure for the Sony Center. On one nine-hour flight. By hand. There was no computer."

Ultimately, the jury offered praise and advice to each student—both of which, the students agreed, young architects and engineers need to become better designers. "Even when I got a lot of heavy criticism, it was really constructive," Bertelsen said. "They really got to the core of the issues. I think I can use that to jump-start future projects."

Others were more pragmatic: "I can finally sleep," Gellis said.

Architecture is about communication

Jahn said it was fun working with the students and hoped they learned something along the way. "I agreed to do this," he said, "because they are involved in this relationship between architecture and engineering and how the integration of those disciplines can make better architects and engineers—and ultimately, better buildings. We architects who are somewhat established have a responsibility to young people, and we tried to teach them that architecture is a business where you've got to sell something. The more successful you are at designing a good building, the easier it is to sell it."

The trip was judged so successful that McCormick plans to offer a similar trip next year. For the students, who headed back to Evanston to finish their studies and prepare for careers in engineering and architecture, the trip provided a new point of view on architecture.

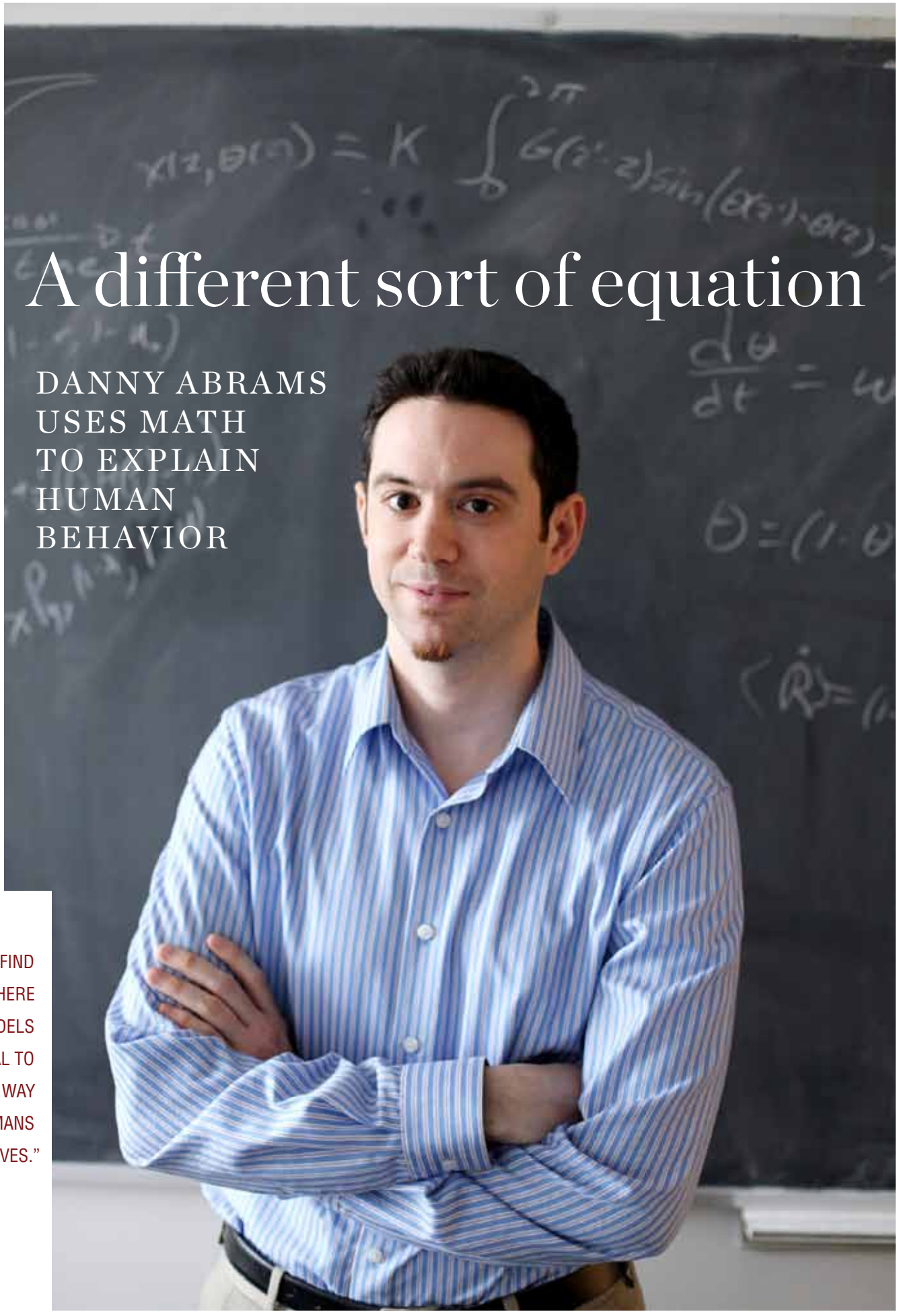
"Architecture really is about communication," Bertelsen said. "If you have a brilliant design but you can't talk about it or draw a picture of it, nobody is going to build it. You need to be able to tell a story. That's probably the most useful thing I learned. And you need to have as many crazy ideas as possible, and then use architecture and engineering to make those ideas concrete."

Patrick Rice (civil engineering '11) believes the trip will give him a leg up when he applies for civil engineering jobs after graduation. "Having experience in an architecture studio will definitely help," he said. "Employers can see I have a commitment to design as well as this technical background."

Booth said he was "blown away" by how worthwhile the trip was for students. "It really has become, in my mind, an integral part of the program." M Emily Ayshford

A different sort of equation

DANNY ABRAMS USES MATH TO EXPLAIN HUMAN BEHAVIOR



"I'M TRYING TO FIND EXAMPLES WHERE MATHEMATICAL MODELS HAVE POTENTIAL TO PINPOINT THE WAY A SYSTEM OF HUMANS BEHAVES."

Photo by Sally Ryan

Danny Abrams readily admits it: "My research is all over the place." Fireflies. Obesity. Language. Religion. All are connected, in Abrams's view, as a series of phenomena that can be explained using similar mathematical tools. Now, back from a four-month research stay in Peru under a Fulbright fellowship and armed with a grant from the James S. McDonnell Foundation, Abrams is using his expertise in synchronization and the physics of social systems to create mathematical models of these phenomena that may ultimately give us a new outlook on human behavior.

Abrams's interest in applied mathematics was cultivated in graduate school at Cornell, where he began working in the area of coupled oscillators, the study of how oscillators behave in groups. An example can be found in groups of fireflies, where the fireflies' random blinking can suddenly become synchronized. "If you have a surface covered with fireflies," he says, "you get certain situations where a portion of those fireflies blink randomly while the rest form a spiral-shaped wave of synchronized blinking. It's a newly discovered type of pattern formation."

Abrams, assistant professor of engineering sciences and applied mathematics, created a model of this wave, which has implications beyond insect biology. In people with certain kinds of heart defects, for example, the cardiac cells around the heart don't expand and contract in time with the heartbeat as normal cells do. Instead, the cells contract randomly or in a spiral wave that rotates around the heart. Abrams's model could help explain how that works.

Synchronization was also a factor in a problem Abrams tackled in graduate school: the opening and subsequent reengineering of the Millennium Bridge in London. When it first opened in 2000, a crowd of revelers began to cross, and the bridge began to sway from side to side. The contractions forced everyone on the bridge to fall into the same side-to-side steps, like penguins, which amplified the shaking.

"Here we had a model of people acting like oscillators," Abrams says. "This natural cycle of the bridge swaying connected people and made them adapt their footfalls. I'm trying to find other examples where mathematical models can be somewhat predictive or have potential to pinpoint the way a system of humans behaves."

Perhaps the social system that most interests Abrams is language: he speaks five of them and says language offers a break from his everyday research. "It's nice not to do math and physics all the time," he says.

Now he's combined his hobby with his research to study the phenomenon of language death. Of the more than 6,000 languages in the world today, most will die with the people who now speak them. Why are so many languages death-bound? Many people point to increased travel and contact between cultures and a greater ability to communicate across language lines. Abrams's approach to the subject is through dual-language cultures, where there is generally a minority language and a majority language and where, as a model that Abrams created shows, only one can survive.

"My model treats languages as though they are competing for speakers," Abrams says. "It shows there is a tipping point where the system goes to one language. It gives some insight into why this is happening all over the world."

In Peru, Abrams researched competition between two languages he has firsthand knowledge of: Spanish and Quechua, an Incan language primarily spoken in the Andes. Abrams studied Spanish in college and graduate school and learned Quechua after being recruited by a professor who stood outside his Spanish class. About 83 percent of Peruvians speak Spanish as their primary language, and about 13 percent primarily speak Quechua. Abrams asked students at the Universidad Nacional de San Antonio Abad del Cusco which language they spoke, which language their parents spoke, and what portion of the people in their hometowns spoke Quechua or Spanish. "I wanted data about how people's social networks affect their probability of changing languages," he says.

Though Quechua isn't in danger of dying anytime soon, it makes a good case for a dual-language model. Studies have shown that two factors drive language change: the majority effect, in which people benefit if they can communicate with more of their peers (and therefore gain an advantage when switching to a majority language), and the status effect, in which society provides greater benefits to those who speak a language that has a higher status. In Peru and much of South America, Spanish is regarded as an urban, higher-class language, while Quechua is mostly spoken in poorer, rural areas. Abrams hopes to conduct a wider survey that will help him expand his model of language competition to include social networks.

Abrams recently received a three-year grant from the James S. McDonnell Foundation, which funds complex systems research. With this money Abrams hopes to study more systems involving groups competing for members. For example, he is working on a model of competition between religious and nonreligious groups using census records from nine different countries. The 2008 American Religious Identification Survey found that Americans who don't identify with any particular religious group are the fastest growing religious minority. In the Netherlands, those who affiliate with a religion are now in the minority. Using his language competition model as a basis, Abrams has preliminary results that show how religious affiliation can shift.

Abrams's research has branched out into other areas of human experience, such as obesity. Obesity rates in the United States stand at 30 percent, and recent studies show that the chance of an individual's becoming obese strongly correlates with obesity rates of his or her social network. Abrams hopes to create a model that shows how biological and social factors affect the way a person's weight changes over time.

Abrams is also interested in why about 10 percent of the population is left-handed. Abrams believe it's an indication of the balance between cooperation and competition in human evolution: If societies were entirely cooperative, everyone would be same-handed. But if competition were more important, one could expect the population to be 50-50. Lefties compose up to 50 percent of top boxers and baseball players, where being left-handed is a key competitive advantage. Abrams hopes to create a model that shows how competition and conformity create the 90-10 ratio.

"As computers and simulation become more widespread in science, it remains important to create understandable mathematical models of the phenomena that interest us," Abrams said. "By discarding unnecessary elements, these simple models can give us insight into the most important aspects of a problem, sometimes even shedding light on things—like human behavior—that are seemingly outside the domain of math." M Emily Ayshford

ROBOTICS

SPECIALIZED MACHINES INSPIRED BY BIOLOGY

Admit it: as a child you thought you'd have a robotic housecleaner by now—like Rosie on *The Jetsons*. Sure, the robotic vacuum the Roomba is one of the best-selling consumer robots, but the humanoid robots that seemed inevitable in science fiction have not yet become a reality.

Over the past 50 years the robotics research community has experienced a series of stops and starts as scientists discovered that the problems of robotic sensing and movement were more difficult than anyone imagined. At McCormick, engineers have set their sights on designing specialized robots that can perform specific tasks—like navigating crowded, murky waters or replacing lost limbs—that humans find it difficult or impossible to do. Six McCormick professors—all winners of National Science Foundation CAREER awards, all well regarded in the robotics field—are working to make some of these specialized robots a reality by focusing on the relationship between engineering and biology, increasing collaboration among disciplines, and partnering with the Rehabilitation Institute of Chicago.

From puppets to prosthetics

Todd Murphey, assistant professor of mechanical engineering, found his somewhat unlikely robotic subject a few years ago when he asked an undergraduate seeking a final project to create a mathematical model of how marionettes move. Around the same time, Murphey met Magnus Egerstedt, professor of electrical and computer engineering at Georgia Tech, who mentioned his collaboration with the Center of Puppetry Arts in Atlanta. "We began talking about how we could create an autonomous puppet system," Murphey says, "and it started to become exciting from a technical engineering perspective." Their ultimate goal is to stage an autonomous robotic puppet show that would be indistinguishable from a human-powered performance.

The implications of their work go beyond a puppet show, of course. The mathematical equations and computational simulations underlying the project could provide a new basis for controlling prosthetics. When Murphey and his group began creating computational methods to simulate marionettes in real time, they collaborated with Wendy Murray, assistant professor of biomedical engineering and of physical medicine and rehabilitation, who uses computer simulation techniques and experimental methods to investigate how we humans move and control our arms and our hands.

These simulations are complicated. Consider a simple action like a hand holding a ball: there is a mechanical connection that runs from the palm through the thumb through the ball and then back through the other fingers before returning to the palm. The mathematics Murphey is using to simulate puppetry turned out to also be useful in creating simulations like Murray's—which ultimately could make better prosthetics.

"We want to be able to take healthy subjects, read electrical activity from their muscles as they move their hand, and see a simulated hand moving with the same motions in real time," Murphey says. "If we can do that, that will be a huge step toward correctly interpreting what the nervous system is attempting to do. Then we could tell a prosthetic hand to make the same motion."

Murphey's goal has turned out to be much more difficult to reach than he anticipated. The group's first 20-second puppet simulation took eight straight days to complete, and it took a year of algorithm development to get that down to less than a minute. The coding for the hand simulation took a year and half. "This project has gotten stuck many times," Murphey says, laughing. "That's why we've learned a lot from it."

Along the way Murphey has met with puppeteers to ask them what they think about when they perform. It turns out they do three related things: they imitate human motions, simplify the movements needed to create those motions, then exaggerate the motions for display on stage. Replicating that process with robots turns out to be a little more challenging. A motion as simple as waving a hand requires movement at both the shoulder and the elbow, making it difficult to seem natural.

In the course of its research, Murphey's team has worked with the Walt Disney Company, which partially funds the project

At McCormick, engineers have set their sights on designing specialized robots that can perform specific tasks that humans find difficult or impossible to do.

Todd Murphey and his puppets, designed by Elizabeth Jochum, a graduate student at the University of Colorado at Boulder. *Photos by Andrew Campbell.*

and is interested in creating autonomous puppets for its theme parks. The group also works with Elizabeth Jochum, a graduate theater student at the University of Colorado at Boulder, who created the puppets for the team's first puppet show: a version of Ovid's *Pygmalion,* in which a sculptor falls in love with his creation. The group also worked with Egerstedt at Georgia Tech and used motion-capture suits to record dancers performing the show; it will use that data to create the numerical model of how the puppets will perform.

In his lab in the basement of the Technological Institute, Murphey and his team have created a makeshift stage where puppets are strung by wires to tiny cars that control the wires while rolling around on a ceiling. The puppets move and wave according to motions made offstage by students using remotes from Nintendo's Wii gaming system.

Murphey hopes to stage a human-controlled puppet show later this year, but the ultimate goal is making the performance completely autonomous. Murphey estimates that is still far off but credits his successes along the way to his collaborations at McCormick.

"The robotics group here is amazing," he says. "We have some of the best people in the country, each doing very different work. For me, the huge motivation in coming here was this diversity of faculty with whom I can collaborate and with whom my graduate students can commingle. I think that's really valuable."

Nature as inspiration

A neuroscientist and engineer by training, Malcolm MacIver, associate professor of biomedical and mechanical engineering, studies the black ghost knifefish, which lurks in the rivers of the Amazon basin. The fish is special: it hunts for prey using a weak electric field around its entire body, and it swims both forward and backward using a ribbon-like fin on the underside of its body. These qualities make the fish an excellent means to understand how a nervous system implements sensing and movement.

The sensory capabilities and agility of the knifefish also make it an intriguing model for specialized underwater technologies, such as plugging a leaking oil pipe or monitoring oceanic environments like fragile coral reefs. A particularly surprising movement of the fish came to MacIver's attention when one of his graduate students noticed the fish suddenly moving vertically in the water. How could it do that? And how could they create a robot that could do that, as well? Further observations and computer simulations revealed that when the fish moved vertically, it did so by creating a downspout of fluid by rippling its fin in a special way. The downspout of fluid causes a reaction force to push the fish up, allowing it to move in a purely vertical way.

> "The robotics group here is amazing. We have some of the best people in the country."
>
> TODD MURPHEY

With this knowledge, MacIver's group hired Kinea Design to design and build a robot that mimicked the fish's maneuverability and electrosensory system. The company, which specializes in human interactive mechatronics and which was cofounded by McCormick mechanical engineering professors Ed Colgate and Michael Peshkin, began to fashion a waterproof robot with 32 motors that each independently control one ray of a spandex-covered artificial fin. (That means the robot has 32 degrees of freedom; in comparison, industrial robot arms typically have fewer than 10.) Seven months and $150,000 later, the GhostBot came to life.

"The robot is a tool for uncovering the extremely complicated story of how to coordinate movement in animals," MacIver says. "By simulating and then performing the motions of the fish, we're getting insight into the mechanical basis of the remarkable agility of a very acrobatic, nonvisual fish."

MacIver and his team hope to improve the robot so it can autonomously use its sensory signals to detect an object and then use its mechanical system to position itself near the object.

MacIver isn't the only professor who looks to animals for clues to sensing: Mitra Hartmann, associate professor of biomedical and mechanical engineering, and her group use the rat whisker system as a model to understand how the brain seamlessly integrates the sense of touch with movement. Using high-speed video to examine the relationship between rat head and whisker movements, Hartmann aims to gain insight into the underlying organization of the nervous system. She has developed several artificial whisker arrays that mimic the sensing powers of rats. One of them is able to use only information about how whiskers bend to determine an object's complete 3-D shape. That technology could find applications on assembly lines, in pipelines, or on rovers or underwater vehicles.

"We're interested in the principles that underlie mammalian brain structure and function and in how information is transformed at various stages in the nervous system," Hartmann says. "The rat whisker system is a wonderful model for looking at these sorts of questions."

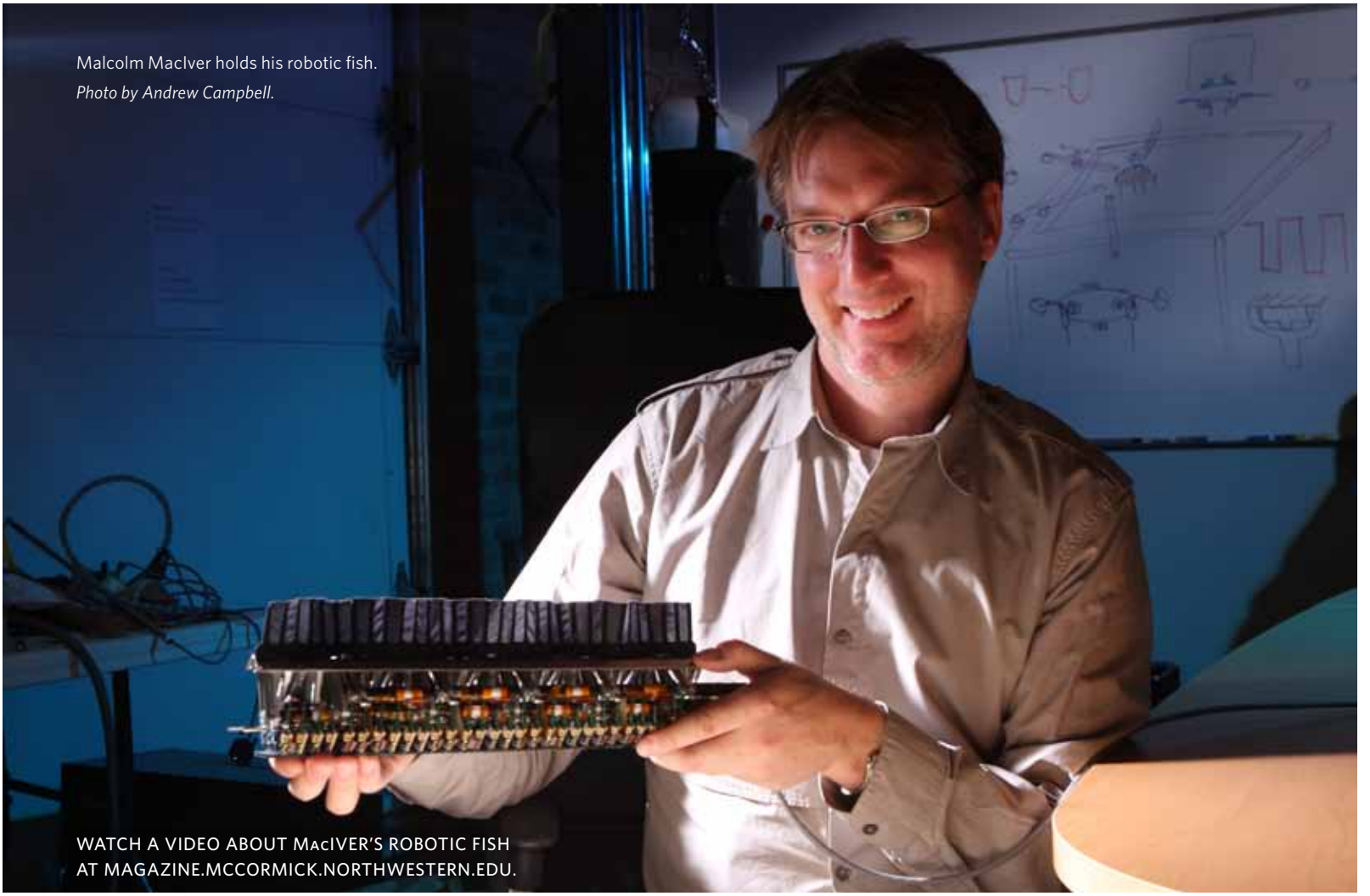
Humans and robots collaborate

The robotics community at McCormick has a solid foundation in the Laboratory for Intelligent Mechanical Systems, directed by Peshkin, Colgate, Murphey, and Kevin Lynch, professor of mechanical engineering.

Lynch's specialty lies in robots that can do dynamic manipulation and locomotion—catching, juggling, running, hopping, and climbing and leaping between two walls. These robots could lead to new military technology for rough terrains where wheeled or tracked vehicles won't work. With colleagues at the Northwestern Institute on Complex Systems, which he codirects, Lynch also looks to swarming behavior in nature (like flocks of birds) to create group intelligence in small "swarming" robots.

In addition, he works with professors at the Rehabilitation Institute of Chicago on restoring arm function to people who have suffered spinal cord injury. The approach is based on functional electrical stimulation, in which stimulators implanted into the muscles are used to bypass the brain-muscle nervous system connection that has been broken at the spinal cord. "RIC is a great resource," he says. "Anybody who does anything with human-robot systems wishes they had RIC nearby."

Colgate and Peshkin have also collaborated with RIC, most notably with Todd Kuiken to create the world's most advanced bionic arm. Kuiken is professor of biomedical engineering at McCormick and of physical medicine



Malcolm MacIver holds his robotic fish.
Photo by Andrew Campbell.

WATCH A VIDEO ABOUT MacIVER'S ROBOTIC FISH AT MAGAZINE.MCCORMICK.NORTHWESTERN.EDU.

and rehabilitation at the Feinberg School of Medicine as well as the director of RIC's Neural Engineering Center for Artificial Limbs.

Using an innovative procedure called targeted reinnervation surgery, Kuiken grafted the nerve endings that once went into an amputee's limb onto the amputee's pectoral muscle. Once the nerve endings grew into their new location, Kuiken and his team could use sensors to read the impulses of the nerve to move a prosthetic limb. Unexpectedly, these nerve endings were also able to receive input, meaning that new prosthetic devices could actually provide touch sensation to the user similar to the way a real limb would. Colgate and Peshkin used their research in haptics—tactile feedback technology that uses touch as an interface—to give the arm "touch feedback" capabilities (see *McCormick by Design,* spring 2007).

"We're interested in how people and mechatronic systems interact," Colgate says. "We're trying to create haptic devices that make that interaction better."

Colgate and Peshkin found success several years ago developing what they called "cobots"—robots that help humans perform tasks. Cobots have been used as high-quality haptic displays, rehabilitation devices, and assistive devices for workers in automobile assembly. This last application has been developed into a spin-off company whose products are now being used in auto plants around the world.

Colgate and Peshkin also remain busy with Kinea Design, which they founded in 2003. In addition to MacIver's fish, the company has created rehabilitation robots such as the KineAssist, which helps stroke patients regain the ability to balance and walk, and, most recently, a robot assisting workers in meat-processing plants to help them avoid repetitive-strain injuries. The company employs six full-time engineers, several of whom are McCormick alumni.

Meeting student demand

Not only has this core group of six professors expanded robotics research at McCormick, they've also provided new mechatronics courses in response to student demand. The popular ME 333 Introduction to Mechatronics course, in which students worked in teams to produce computer-controlled electromechanical projects of their own design, has been expanded into a three-course sequence of electronics design, embedded computing, and mechatronics projects. A new lecturer, Nick Marchuk (MS '10), is also working to expand the curriculum and runs the annual Design Competition, in which students design, build, and program robots to operate autonomously.

All of these faculty members work together on research projects, and in the next two years they will move into new shared lab space in an expansion of the Technological Institute.

As Colgate says, "McCormick is a force to be reckoned with in the robotics world."

M Emily Ayshford

@Social Media

Using Twitter and Facebook to understand how networks—and people—behave

For most people, social network websites such as Facebook and Twitter provide easy real-time updates on the activities and opinions of friends and celebrities. But for computer scientists these sites provide large data sets that enable new research possibilities. Two professors at McCormick are using social networking to establish new platforms for Internet communication and security.

Alok Choudhary. *Photo by Sally Ryan.*

#DATAMINING: ALOK CHOUDHARY

Which celebrities had the most influence on Twitter was the furthest thing from Alok Choudhary's mind when he started his work with data mining—the process of gleaning patterns from large data sets. Initially, he set out to analyze research on protein interactions, which are the basis for every process in cells. A database of protein interactions could help improve the understanding of diseases and lead to possible treatments.

To do this, Choudhary, the John G. Searle Professor and chair of electrical engineering and computer science, began searching through thousands of articles in scientific journals and developed data mining software that could identify specific outcomes from the papers. The software used such processes as high-dimensional clustering, classification, and deviation detection, which businesses have used to understand customers' preferences and help enable recommendation tools (like the one used by Amazon.com).

But Choudhary and PhD student Ramanathan Narayanan wanted to extend their research beyond a static network into real-time data mining. What could an evolving network tell them about the nature of news and information today? So they turned to the ultimate real-time data behemoth, Twitter, where users offer up their diatribes, opinions, news flashes, and announcements in 140 characters or less.

"The tweets are so small and so numerous that they make an easily accessible large database of real-time information," Choudhary says. "We wanted to know how people followed opinions on important topics." Choudhary and Narayanan developed software for pattern recognition that could identify and measure sentiment—which would come in handy to determine whether tweets were positive or negative—and they set up a website: pulseofthetweeters.com. They began using data mining, social network analysis, and sentiment analysis to determine top influencers on Twitter and how tweeters felt about top trends.

At pulseofthetweeters.com, users can search for a topic (such as Justin Bieber), judge user opinions (83 percent positive), and see which tweeter is most influential (fellow pop star Demi Lovato). But trends and influencers aren't always that straightforward: For the Chilean miner rescue, talk show host Conan O'Brien was the most influential tweeter. For the Haitian earthquake, the biggest influencer was singer Adam Lambert.

"We can determine who is helping to shape opinions," Choudhary says. "Our real-time analysis can determine public sentiment on any given topic quickly, because 15 minutes later another topic or event might be a top trend."

Choudhary and his colleagues have developed a specialized algorithm to rank influence; to qualify as an influencer, a tweeter must actively tweet about the topic and have a following that subsequently tweets about it, too. "Influence determines the value of communication," he says. That, he says, could prove especially valuable in marketing. "If a company wanted to target its communication, it could figure out who its influencers are and see how its message or brand is received."

Earlier this year, Choudhary and his team released a list of the top Twitter trends of 2010. Lady Gaga, Mel Gibson, and Justin Bieber were among the most tweeted-about people, and national news organizations NPR News, the *New York Times,* Time.com, CNN, and the *Wall Street Journal* were often top influencers on politics and world affairs. Top sports topics included Lebron James, Brett Favre, Michael Vick, Wimbledon, and Manchester United, and in the trending topic #thankful, in which people tweet about what they are thankful for, Bieber was the most influential.

The website has gotten major media attention, but Choudhary says he is most interested in continuing to develop new techniques in data mining—including a research project that determines the impact of climate change around the world. "We didn't start out expecting to be looking at these things," he says. "We wanted to discover patterns in data, and popular culture is a major part of Twitter and the data we mine."

Visit McCormick's Facebook page:
facebook.com/mccormickengineering

Follow McCormick on Twitter:
twitter.com/nu_mccormick

STATUS: SPAM

Someone has a crush on you. Get free ringtones. Check out this cool video. It's easy: Just click here.

For the 500 million Facebook users worldwide, these wall posts are a common stain on the fabric of social networking: malicious spam that redirects users to sites that ask for personal information or install viruses onto unsuspecting users' computers. But just how prevalent are these posts? How do they work? Where do they come from?

Those are the questions that Yan Chen, associate professor of electrical engineering and computer science, and his collaborators at the University of California, Santa Barbara, set out to answer when they conducted the first study that quantifies the extent of malicious content and compromised accounts in a large online social network.

Analyzing more than 187 million Facebook wall posts, the team found 200,000 malicious messages with embedded URLs, more than 70 percent of which linked to phishing sites that ask users for their passwords or other personal information. Their research results could help programmers design techniques to automatically detect online social spam.

Chen's team used data gathered from the Facebook walls of 3.5 million user accounts. By "crawling" the user sites of eight regional networks (Egypt, Los Angeles, London, Monterey Bay, New York City, Russia, Santa Barbara, and Sweden) from April to June of 2009, the researchers were able to download users' publicly available wall posts from the last year and a half. They narrowed their search to the messages containing URLs—about 2 million.

Researchers then sorted the posts based on destination URL or strong textual similarity, with the assumption that similar spam posts would come from the same spam campaign. They found about 200,000 posts were embedded with malicious URLS. They analyzed the posts for two distinguishing features: distributed coverage and "bursty" nature. Distributed coverage refers to the number of users who send wall posts. "Bursty" describes the small time intervals between consecutive wall posts; most spam campaigns involve coordinated action by many accounts.

Using third-party tools to assess the malice of URLs in their dataset, Chen and his team found that approximately 70 percent of malicious wall posts direct the victim to a phishing site. About 35 percent of malicious wall posts direct victims to sites laced with viruses. Chen also found that the vast majority of those wall posts came from existing, hacked accounts. "It's much easier to create a fake account, but attackers who hack into existing accounts can have a higher rate of success because there is a level of trust among real friends," he said.

The most popular ploy was a message that said someone had a crush on the user. Tempting, no doubt, but Chen urges Facebook users to stop and think before they click. "Don't trust a suspicious wall post even if it's from your friends," he says. "And alert your friends immediately."

Yan Chen

The attacker usually has control of the account for a short period of time—about 80 percent of malicious accounts are active for less than an hour. Most malicious wall posts are posted at 3 a.m.—when most users are asleep.

So how can online social networks fight back against spammers? Facebook has started trying to eliminate fake accounts by launching a new feature allowing users to reject friend requests as "don't know." Facebook collects this information to identify and remove spammers.

Spamming on Facebook highlights one of the major communication issues of our age: because it's so difficult to categorize and understand the huge volume of traffic on the Internet, it's difficult to design security procedures to protect users. Chen and his research group are on the front lines of this battle. They have previously analyzed attacking strategies of spammers and designed intrusion detection and prevention systems for networks. His group takes two approaches to improving the reliability and security of the Internet: designing network-based intrusion-detection and -prevention systems to combat large-scale attacks and creating new protocols and architecture to improve the reliability and security of the Internet.

"A lot of security breaches can be stopped by patches that were released months or years ago, but users do not pay attention," says Chen. "We want to develop a networking-based approach that we can deploy at routers and gateways so we can protect users automatically."

Real-time detection of spammers that compromise social networking accounts is still far off, however. "We need much more research," Chen says. "There's no good solution yet, and attackers are becoming a lot more powerful. They have their own mature society—their own forums, banks, and markets—and they often prey on security breaches that have already been fixed with patches. We need more people to be aware of security problems in order to stop them."

That sort of large-scale impact is ultimately what drives a computer scientist like Chen, who says, "I ultimately hope that this research can have a direct impact on society's well-being." Emily Ayshford

McCormick: A family tradition

When most people talk about the "McCormick family," they're referring to the school's close-knit community and the collegial atmosphere that spawns countless collaborations and decades-long careers. But for some people, that phrase can be used literally. McCormick has been home to many legacy enrollments over the years, as sons and daughters (and sisters and brothers) inherit an appreciation for all the school has to offer and set to work creating their own traditions. We've spotlighted a few students, past and present, who are truly members of a "McCormick family."

Brotherly love

When Phil and Brian Brunner were playing with Legos and Lincoln Logs as kids in their Milwaukee home, they were doing more than having fun; whether they realized it or not, the brothers were taking the first small steps in their academic careers. "We just had an interest in building things," says Phil. "That's what engineering is all about."

Nearly two decades later, the two are playing with bigger toys at McCormick. Phil ('08, MS '09), who is now pursuing a PhD in materials science, was a talented high-school quarterback who came to Northwestern for reasons that were not strictly academic. "I wanted to challenge myself both intellectually and athletically, and Northwestern is the place to do that," he says. A walk-on to the football team, Phil was the Wildcats' long-snapper for three seasons and earned Academic All-American honors.

Brian (BS/MS '11) joined his older brother at McCormick a few years later. "Phil drew me toward the school," he says. "I knew that if I followed him, I would have some guidance." That guidance mainly included advice about which residence hall to live in (Elder Hall) and reminders of how hard engineering courses would be. But both brothers appreciate the presence of a familiar face. "It's nice having someone there to listen when you're blowing off frustrations," says Phil. "At least I think he's listening."

The Brunners live together in an off-campus apartment and even took the same class last year, but they don't share every interest. Brian won't be getting a PhD, for example. "I'd rather just start working and get some experience," he says.

Brian will be moving on to a commercial plastics company after graduation, while Phil will be continuing his research on plastics. Will there be a collaboration down the road, perhaps including the pair's three brothers, all engineers? If it does happen, Phil is optimistic. "I wouldn't want

Brian and Phil Brunner. *Photo by Andrew Campbell.*

While the full list of alumni with McCormick family ties is far too long to print, perhaps you'll recognize some familiar names here:

Thomas Anderson ('56, '58, '61); daughter **Patricia Morreale** ('83); son-in-law **James Morreale** ('84)

Jeffrey K. Braun ('65); sons **David Braun** ('90) and **Kenneth Braun** ('94)

Ronald Church ('58); sons **Stephen Church** ('86) and **Timothy Church** ('90)

William ('81) and **Carol Cory** ('79); daughter **Christine Cory** ('11)

Lee A. Dayton Sr. ('65); son **Lee. A. Dayton Jr.** ('87)

David Eckert ('77); brothers **Alfred C. Eckert III** ('71) and **James Eckert** ('72); son **John Eckert** ('08)

John Eshbach ('46, PhD '47); son-in-law **A. Eugene Norby** ('68)

Robert Fierle ('45); son **William Fierle** ('98)

Edwin P. Garst ('70); sons **James Garst** ('00) and **David Thomas Garst** ('01)

H. Wallis Gochnauer ('44); son **Richard Gochnauer** ('72)

Philip Graham ('60); daughter **Sarah Marshall** ('98)

Thomas and **Louisa H. Gross** (both '77); children **Mary Gross** ('06), **James Gross** ('08), **Carol Gross** ('10), **Susan Gross** ('10), and **William Gross** ('14)

Promod Haque ('74, PhD '76); daughter **Irene Haque** ('11); son-in-law **Chad Cochran** ('10)

Bernard Hattis ('43); sons **Jonathan Hattis** ('73) and **Philip Hattis** ('73)

Melville and **Jane Hodge** (both '52); nephew **Linn Hobbs** ('66)

Mark and **Patricia Hutten** (both '85); son **Ryan Hutten** ('12)

Fred K. James ('49); sons **Frank James** ('68), **Paul James** ('70), and **Keith James** ('76)

Raymond Krizek ('63, Stanley F. Pepper Professor of Civil and Environmental Engineering); sons **Robert Krizek** ('87) and **Kevin Krizek** ('93)

John Kukral ('82); son **James Kukral** ('13)

Robert Linsenmeier ('75, PhD '78, professor of biomedical engineering and of neurobiology and physiology); son **Jeremy Linsenmeier** ('07)

John ('80) and **Lori** ('81) **Luther**; son **Matthew Luther** ('10)

Lyle Mockros ('56, '57, professor emeritus of biomedical engineering); son **Karl Mockros** ('86)

Emil C. Muly Jr. ('58, '62) and **Faye Muly** ('61); daughter **Emily Schmidt** ('91); son-in-law **Brian Schmidt** ('85)

D. Eugene Nugent ('51); son **Dale Nugent** ('92)

Samuel Pai ('78); daughter **Christina Pai** ('13)

Warren Rasmussen ('53); son **Mark Rasmussen** ('81); daughter-in-law **Nancy Rasmussen** ('80)

Damoder Reddy ('67); son **Sridhar Reddy** (PhD '93)

Ginni Rometty ('79); sister **Annette Peterson** ('86)

William Rosner ('75); children **William Rosner** ('05), **Kathryn Rosner** ('07), and **David Rosner** ('10)

to work with anyone other than my brothers," he says. "They all work hard. They're all very intelligent people. I think we can take criticism very well. I can yell at Brian, and he's not going to go pout or anything." His younger brother has a slightly different take: "I always told him that we might work together," says Brian, "but I'll never work for him."

As for the next generation of Brunners, Phil will do his best to further the McCormick tradition. "I'm definitely going to encourage my kids to look at Northwestern. I really love it. That's why I stayed here another four years."

Glenn and Ralph Daehn

Like father, like son

It's not surprising that Glenn Daehn ('83) was drawn to engineering. He spent his formative years following his father, Ralph (MS '75), around manufacturing plants, previewing the career that awaited him. "That kind of stuck with me," he says.

"I think Glenn saw how much enjoyment I had with my work," says Ralph. "I traveled all over the world, did a lot of fascinating things, and have been able to provide very well for my family."

Ralph says his time at Northwestern, where he earned his degree in materials science and engineering taking weekend courses, was a big factor in his career success. When the time came for Glenn to consider colleges, his father set up a meeting with former McCormick professor Julia Weertman, who would become a friend and colleague of the younger Daehn, now a materials science professor at Ohio State University. "Like most kids that age, I didn't have a strong sense of where I was going or why. My dad's influence definitely pushed me toward engineering," says Glenn.

Glenn's enrollment marked the beginning of a deeper relationship between father and son. The two worked at the same company during subsequent summers and continue to consult each other regarding engineering issues. "Sometimes he'll call me for technical advice, or I'll call him and say, 'Hey, I've got this problem. What do you think about this?'" says Ralph, who now works as a consultant after more than 40 years in the containers industry.

Both Daehns have been elected fellows of ASM International and shared the head table at the society's awards event last October (Gregory Olson, the Walter P. Murphy Professor of Materials Science and Engineering, was also honored).

Glenn's daughter, Katie, a high school senior, may be continuing the family's engineering tradition at McCormick. The Daehns visited campus over Christmas break and were welcomed by an old family friend, associate dean for undergraduate affairs Stephen Carr, who taught both Ralph and Glenn.

The Daehns cite their interactions with faculty as a major benefit of their time at Northwestern. "I was extremely pleased with the professors I had," says Ralph. "They were so professional and down to earth." Glenn has been invited back several times to give talks at McCormick, most recently last fall. "I've got great memories of Northwestern and still consider many of the people here friends," he says. It's just one more thing he and his father have in common.

My three daughters

Growing up with parents who worked at Northwestern, the Wolff sisters were introduced to an array of attractions at the school from a very early age: football games, enrichment programs, Cheetos from the Tech Express vending machines. "I thought Northwestern was the only college that existed," says Grace, 17, the youngest of the three.

"Being around Northwestern so much could have repulsed them so much that they wanted to get as far away as possible, but I think it gave them a glimpse of what a great place this truly is," says the girls' father, Alan Wolff (PhD '08), McCormick's director of information technology.

Given the choices of all three sisters—Sarah is a junior studying environmental engineering, Esther is a sophomore in manufacturing and design engineering, and Grace will enter McCormick in the fall—it's safe to say that the family's close ties to Northwestern were beneficial. "Our dad geared us toward all the resources at McCormick and even introduced us to some department chairs," recalls Sarah, who enrolled in the engineering and law program, which she would not have known existed if not for her father.

The sisters inspired each other, too. "I used to think engineering was really boring," admits Grace. "Then during Sarah's freshman year, she had to redesign a Wii for a stroke patient [in the Engineering Design and Communication sequence]. I thought it was the coolest thing ever."

Esther was similarly drawn to McCormick's focus on practical applications. "You do a lot of hands-on stuff here," she says. Esther has put those skills to use in an internship at Solo Cup, while Sarah has worked as a co-op student for General Electric.

Though Alan says he isn't much help with homework, he still acts as a valuable resource for his daughters. "Occasionally they wanted to know where a certain room in Tech was, and I could tell them exactly where it was," he says.

The Wolffs are enjoying this relationship while it lasts. "This is a good college choice for them, but they don't necessarily have to stay here like I did," says Alan. "I think this is an excellent launching pad to something else."

Regardless, the Wolff family legacy at McCormick will continue. For years Alan, his wife, Vivian, the three girls, and their younger brother have been regulars at the annual undergraduate Design Competition, where autonomous robots are pitted against each other. That tradition is likely to live on long after the sisters have graduated.

M Ben Rubenstein

The Wolff family (clockwise from top left): Grace, Alan, Esther, and Sarah.
Photo by Andrew Campbell.

Stephen Schwartz ('74); son **Samuel Schwartz** ('12)

Ben Slivka ('82); son **Max Slivka** ('12)

Michael Stark ('78); son **William Stark** ('14)

Gregory P. Stewart ('69); sons **Gregory P. Stewart** ('90) and **Brett B. Stewart** ('93)

William Templeman ('50); sons **William J. Templeman Jr.** ('76) and **Robert Templeman** ('85)

Grant Tiefenbruck ('73); daughter **Laura Tiefenbruck** ('00); son **Mark Tiefenbruck** ('04)

William White ('61, professor of industrial engineering and management sciences); son **James White** ('85)

Visit **http://magazine.mccormick.northwestern.edu** to see more McCormick families and to submit your family story.

We'd love to hear from you.

Alumni Profile: **Gwynne Shotwell**

Growing up, Gwynne Shotwell was always good at math and science, and she was always curious about how things worked. But when she began thinking about a career in high school, Shotwell, couldn't see herself using her strengths in engineering. She was terrified of becoming, well, **nerdy.**

So how did she go on to receive both an undergraduate and master's degree from McCormick?

"That was my mom's fault," she says. Shotwell's mother took her to a Society of Women Engineers panel for teenage girls, and there she met a female mechanical engineer who owned her own business. "I loved what she had to say, loved her perspective—and she wasn't all that nerdy," Shotwell says. "I thought, 'It's okay to be a woman and an engineer.'"

The choice has served her well: Shotwell is now president of SpaceX, one of the most innovative companies in the country. A space transport company started by PayPal founder Elon Musk, SpaceX (short for Space Exploration Technologies Corp.) has developed two space launch vehicles—Falcon 1 and Falcon 9—and the Dragon spacecraft, which will deliver cargo to the International Space Station for NASA. In December 2010 SpaceX became the first private company to successfully launch, orbit, and recover a spacecraft.

But back in 1982, Shotwell was a freshman navigating her way through introductory engineering courses. She can remember when the Wildcat football team broke its 49-game losing streak, and she can remember suffering a few setbacks in her engineering classes—specifically, 3-D Rigid Body Dynamics.

"I didn't do great on the midterms," she said. "But when I was studying for the final, it just clicked for me." She got one of the highest grades in the class. "I remember the professor looking at me, surprised, in a way that said, 'Well done.' That was a great memory."

While at Northwestern, Shotwell took advantage of the school's wide-ranging opportunities to create her own version of what McCormick now calls a whole-brained engineering education. "I really wanted to go to a university that had a broad perspective on education," she says. "I had great economics professors, I took an art class, I went to all of the theater events. It was a very well-rounded experience that helped me personally."

After receiving an undergraduate degree in mechanical engineering in 1986 and a graduate degree in applied mathematics in 1988, Shotwell went on to work in space systems engineering and technology at the Aerospace Corporation, where she quickly moved up the ladder. She was recruited to be director of the space systems division at Microcosm before joining SpaceX in 2002 as vice president of business development. In that role, she developed SpaceX's customer base and managed strategic relations. She was named president in 2008.

> "I just loved what Dean Ottino had to say about whole-brain engineering. That really struck a chord."
>
> GWYNNE SHOTWELL

Shotwell's career has evolved naturally from engineer to manager because she isn't "that person who wants to sit at my desk and work without talking to anyone. I want to go out and be part of a team, work on projects, communicate," she says. "I always wanted to talk with people and find the gaps between one person and another person. It's bridging those gaps and interfaces where I felt like I could contribute the most."

Shotwell was SpaceX's seventh employee when it was founded in 2002—now the company boasts over 1,250 employees, three launch sites, a rocket-development facility in Texas, and a 550,000-square-foot factory with offices in Hawthorne, California. The company designs, manufactures, and tests the majority of the components of its space vehicles in house. Next, the company hopes to make its Dragon spacecraft ready for human transport, upgrade the engine for its rockets, and launch a new rocket for lifting heavy payloads into space.

"We've got a lot of development sitting in front of us," she says. "We're busy." Yet Shotwell made time this fall to come back to Northwestern and speak to faculty and students at McCormick's Dean's Seminar Series. She was appointed to the McCormick Advisory Council, and she will come back this June as McCormick's convocation speaker.

"I just loved what Dean Ottino had to say about whole-brain engineering," she says. "That really struck a chord with me. That's why I selected Northwestern."

While visiting McCormick, Shotwell also met with students who were interested in interning at SpaceX, and she hopes to continue that recruiting relationship in the future. "It was just time to start reaching out," she says. "Northwestern is an awesome school. We wanted to make sure we were engaged here."

Shotwell advises undergraduates who are looking to emulate her success to work on real projects. She says it's only through developing a project, testing it, and deploying it that you truly learn the engineering process.

"You need to understand the theory," she says, "but you've got to be able to put that to work." M Emily Ayshford

Clockwise from left: Gwynne Shotwell; the Dragon spacecraft; the Falcon 9 rocket launches the Dragon spacecraft into orbit on December 8, 2010—a flight that made SpaceX the first private company to launch and recover a spacecraft from orbit; the Dragon spacecraft at Cape Canaveral in December 2010. *Photos courtesy of SpaceX.*

MURPHY SOCIETY DONORS

The Walter P. Murphy Society honors individuals for their annual gifts of $1,000 or more to the McCormick School. Members have a unique opportunity to assist the dean in making decisions to fund faculty and student initiatives through Murphy Society grants. The society honors the legacy of Walter P. Murphy, the benefactor whose gifts supported the construction of the Technological Institute.

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Robert B. Taggart '67, MS '68 and Donna F. Taggart
Antti P. Talvitie, MS '68, PhD '71
Charles Thomas and Cary Meer
John M. Torkelson
Joseph Tort and Miriam Tort
James E. Van Ness, MS '51, PhD '54 and Mary Ellen Van Ness
James N. White '85 and Patricia White

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$2,500 to $4,999

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Marcus Aaron Hogue, MIT '10
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Tetsuo Iwakuma, PhD '83
Troy R. Karlsson '84
Ali Kassamali and Teresa Kassamali
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Timothy K. Krauskopf '84, MBA '99 and Mele Howland
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Mark J. Morton '66
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J. Howard Speer Jr. '53 and Catherine Kerins Speer '52, MA/MS '53
Derek A. Steelberg '86 and Maria Vignali Steelberg '87
Iren Suhami, MS '77, PhD '80
Chin-Teh Sun, MS '65, MS '67
Gary F. Teletzke '78
Edward F. Voboril '65 and Melanie Fraccaro Voboril '64
Ira Wagner and Marcia Wagner
Robert W. Waldele '72
Sheldon M. Wecker, MS '70, PhD '73 and Gail E. Wecker
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Ying-Hon Wong '79, '79

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Irene H. De Sanctis
Guy H. Deboo '76 and Susan Mary Franzetti '76
Tushar Heramb Dhayagude, MEM '01, MBA '01 and Aparna Dhayagude
Lisa Chang-An Diller MS '93, PhD '96 and David J. Diller MS '93, PhD '96
David A. Dixon '63, MS '64, PhD '66
Donald A. Dobson '50, PhD '55
Richard K. Dompke '55 and Gayle Kenney Dompke '58
William R. Drake '77
Charles B. Dunne III '69
Reggie Dupre
Martin M. Eisman, MS '67 and Carol Baeder Eisman '67
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Susan H. Ellis
Larry G. Evans, PhD '71
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William O. Gentry, PhD '71
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Steven Gilbert, MS '86
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Marilyn Otto Goll '46
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Michael J. Gordon '92 and Amy Gatewood Gordon '91
Jeffrey T. Gotro, PhD '83 and Elaine M. Grossman-Gotro '79
Philip H. Graham '60 and Linda Robinson Graham '60
Mark Greenberg and Carol Greenberg
Steven Abraham Gross '76 and Julia L. Winston
Paul R. Gudonis '76
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Jeffrey Halpern
Eva B. Hamilton
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Bruce S. Harrison '82
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Walter H. Hickel '52
David Curtis Hinton '95
Cynthia S. Hirtzel, MS '77, PhD '80
Craig V. Hodson '69
Jeffrey N. Hoffner, MS '73
Carl J. Holdampf '51 and Margaret Miller Holdampf '51
Jon S. Holmgren '62, MS '66
Duane D. Hong '97
Don J. Howard '63
Paul A. Humiston Jr. '60 and Gretchen Bower Humiston
Arthur P. Hurter '56, MS '58, PhD '62 and Florence E. Hurter
Robert A. Iehl '47
Adam Inselbuch
Kiyoji Ishida, MS '68
Hitoshi Ishii, PhD '71
Thomas A. Jacobik '87 and Elizabeth Jacobik
Paul A. James '70 and Pamela Butler James '71
Dennis C. Jans '72, MMgt '76 and Georgia Yeager Jans '72
D. Lynn Johnson
Scot Jones and Jacqueline Beshar
Wendee W. Kanarek
Jeffrey P. Kao '97
Donald Kaplan and Evelyn Karson
Jenifer Serafin Kennedy, MS '89, PhD '91
Robert J. Kiep '88
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Herbert P. Krog '56
William J. Kroll Jr. '67, MS '71
Robert J. Kudder, MS '72, PhD '78
Sharad Kumar
Stephen R. Larson '67 and Marcia Kempe Larson '73
Harvey Y. Lee '88
Michael T. Lee '84 and Denise Skelton Lee '84, MS '86
Ven-Gen Lee, PhD '93
Jeffrey Richard Lefebvre, MS '86, PhD '92 and Julie Kompare Lefebvre '87
Susan Adomeit Leichliter '67
Peter B. Leichliter '95
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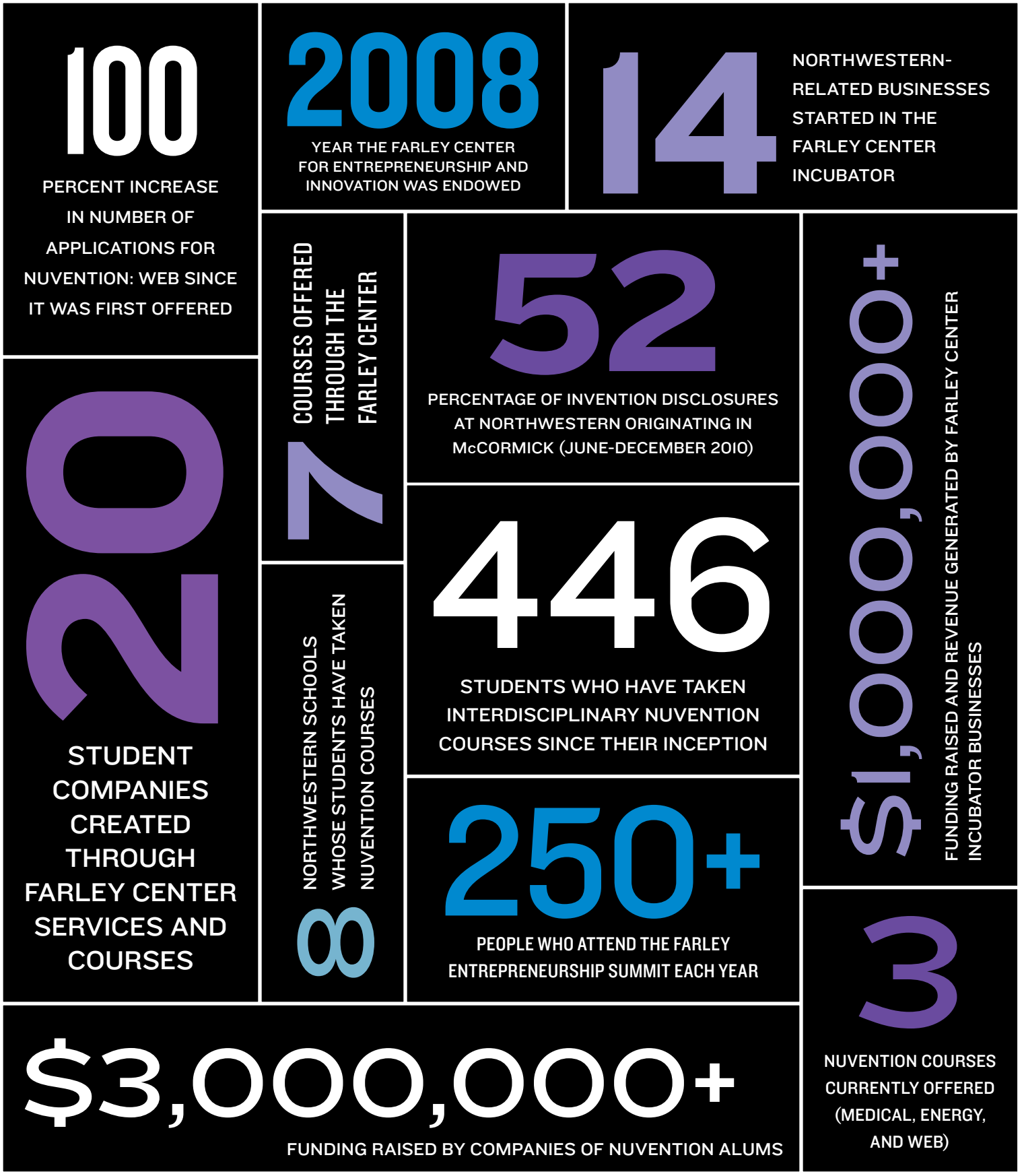
Neal I. Leland '93
Steve Liao '92
John C. Lieske '82
Marc K. Linhardt '93 and Maureen Murzyn Linhardt '93
Richard J. Long '65
Robert A. Long '81 and Sheryl Loyd Long '81
Michael S. Lurey '67
Michael C. Madsen '68
Harry Major '70, MBA '72 and Lauren Major
Michael S. Mapes '00
Anne M. Mayes, PhD '91
Myron J. McKee Jr. '48
Gregory W. McKinney, MS '83 and Nancy Lubich McKinney
Benjamin James McLean '99, JD '05, MBA '05 and Rachel Ruan McLean '00, MA '03, PhD '05
Charles S. McNeer '50
Eric M. Meredith '95 and Jennifer A. Meredith '95
Gaylord M. Messick '61
Joel D. Meyer and Enid Meyer
Darrell P. Mieseler, MS '76
Tsuyoshi Mifune, PhD '69
David Mintzer and Justine Klein Mintzer
James J. Morreale '84 and Patricia Anderson Morreale '83
Clyde Victor Moseberry, MS '97, PhD '05
Clifford A. Moses '65, PhD '74
Mrs. Toshio Mura
Michael J. Murphy '95'95
Geoffrey C. Murray, PhD '95 and Lisa S. Murray
Philip David Murray '78, MS '78 and Leslie Murray
Peter C. Nelson, MS '86, PhD '88
George L. Nemhauser, MS '59, PhD '61 and Ellen Krusaw Nemhauser '61
Scott G. Norquist '95 and Penny Norton Norquist '96
Kristin Guy Norton '91
Philip E. Novak '57
William I. Nowicki '79 and Elizabeth R. Nowicki
Ryan W. O'Nell '00
William B. Olson '51 and Jeanne Caldwell Olson '50
Kanji Ono, PhD '64
Fred J. Osborne '83'83
J. M. Ottino and Alicia I. Löffler
Terry L. Overbey '72 and Lynette Pudvin Overbey '71
Fon-Tsao Pai and Hsiao-Shu Hung
Garo A. Partoyan '59
Robert L. Peskin, MS '75, PhD '77
Gerald T. Petersen '57, CERT '74 and Carol Krametbauer Petersen '56
Robert A. Phillips '63, MS '65, PhD '72
Chad B. Pierce '44
Richard E. Plotzker '73, MD '77
Kimon Proussaloglou, MS '88, PhD '92 and Popi Proussaloglou
Mark S. Pucci, PhD '82
Robert L. Puette '64 and Mrs. J. P. Puette
Donald E. Rathbone, MS '57
John S. Reilly '95 and Cynthia L. Mount '95
Robert D. Reilly '47
Anthony J. Risica, MS '81
Sung Woo Roh
Donald E. Rome '77
D. Daniel Rotenberg '86
Kanji Sahara, MS '59, PhD '61
Akikazu Sato, PhD '72
Gilbert T. Satterly Jr., MS '65
William E. Saul, PhD '64
Timothy J. Scale, MS '75, PhD '80 and Laural L. Briggs '73, PhD '78
Alan L. Scharff '46 and Sandra Evelyn Scharff
Paul H. Schipper, MS '75, PhD '77
Logan H. Schlipf '51
John H. Schmertmann, MS '54, PhD '62
Walter G. Schmid, MBA '71 and Leslie Adickes Schmid, MBA '98
Arnold L. Schmidt '54 and Ann Atkins Schmidt
George L. Schneider '60
Joseph L. Schofer, MS '65, PhD '68 and Nancy L. Schofer
John K. Scholvin '89
Deborah Lee Schuh '82
William E. Schultz, MS '67 and Virginia G. Schultz
Bruce H. Schwartz '82 and Sheila Jurzyna Schwartz '82
Lyle H. Schwartz '59, MS '64
Stephen L. Schwartz '74, MMgt '76 and Terry Schwartz
Robert W. Semmler '50
Matthew M. Shemluck '99
Richard B. Silverman and Barbara K. Silverman
Narinder Singh '95
Michael H. Sitko, MS '89
James C. Skelton '64
Alice Zajakala Sloma
George R. Smith '53 and Lois M. Smith
Mariel Spalter '89
Jeffrey Staab '83 and Sara Hippe Staab '84
Robert Harmon Stallard '76 and Ann Wright Stallard '76
Gregory M. Stanley, MS '74, PhD '77 and Linda Wang Stanley, MMgt '76
David H. Stieber '49
Stuart Stock '77, MS '78 and M. Christine Janicke Stock '79, MD '81, GMER '84
Burton L. Streicher '72
Theodore A. Struve '57, MS '64, PhD '65 and Gail Reinholtzen Struve '57
Andy Hok-Fan Sze, MS '74 and Lola Sze
Ronald J. Tabar '73
Keiko Takahashi
Kunio Tamura, PhD '71
Troy D. Tepp '90
Audrey Seelig Timkovich '85
William C. Trotter '58
Paul D. Ulland '66 and Judy Ulland
John W. Van Ness '59
Prashant R. Velagaleti '02, MPD '07
Jerome E. Vielehr '57
Mary M. Vondrak '82 and Patrick G. Kirk '81
Harvey E. Wahls '54, MS '55, PhD '61
Samuel A. Walker III, MS '71 and Joanne Walker
Samuel Chih-Hung Wang, MS '75, PhD '79 and Sujane Chang Wang, MS '78, PhD '81
Nina Joag Waranica '85 and Gregory P. Waranica
Raymond Noble Wareham '70
Michael J. Warga '80 and Susan Hague Warga '81
Sharon Sue Warsaski '84, MS '90
Paula Chambers Waterman '97 and Jeffrey S. Waterman '95, MSED '06
Michael Stephen Watson, MS '93, PhD '96 and Kristin Paulson Watson, MMgt '97
Howard J. Weiss, MS '73, PhD '75 and Lucia Beck Weiss
Bruce W. Wessels
Richard V. Westerman '63 and Carla Westerman
Arthur R. Whale '45 and Roberta Donaldson Whale
Charles S. Williams, MS '80
Donald R. Wilson '46
Jessica Lutkenhaus Winter '97 and Adam E. Winter '97
Alan Richard Wolff, MSC '96, PhD '08 and Vivian Wolff
William A. Woodburn, MS '75
Dean A. Worrell '77
Marla L. Wright '93
Susan Wright '73
Walter Wundrow '80 and Diane Wundrow
Jack Yap
Stephen M. Zavoluk, MS '70 and Nancy Ehrenberg Zavoluk, MSEd '68
Thomas J. Zlatoper, MA '74, PhD '80
James L. Zydiak, PhD '89 and Katrina L. Helmkamp '87, MMgt '92

Entrepreneurship *by the numbers*



CLASS NOTES

1940s

Lester Crown ('46) is chairman of Henry Crown & Co., which has entered the suburban office market with the purchase of three office buildings in Oak Brook, Oakbrook Terrace, and Clarendon Hills, Illinois.

1960s

David J. Kuck (MS '60, PhD '63), a researcher in Intel's software and solutions group and an Intel Fellow, was the recipient of the Theodore M. Matson Memorial Ward, which recognizes outstanding contributions in the field of traffic engineering.

Jim Brown ('62, MMgmt '67) of Naperville, Illinois, wrote *More than a Game: A Vehicle for Child Development* (Legacy Book Co., 2009). The book uses football as a vehicle for child development and teaches how to create and lead high-performing teams in business, family or sports. Brown has coached youth sports for 41 years.

David A. Carlson ('62, Kellogg '64), a technical adviser to the Fibre Box Association in Elk Grove, Illinois, received the TAPPIE Corrugated Packaging Division Lifetime Achievement Award.

John N. LaPlante (MS '62), director of traffic engineering for TY Lin International, received the Theodore M. Matson Memorial Award, which recognizes outstanding contributions in the field of traffic engineering.

Charles R. Buck Jr. ('64) of Naples, Florida, received the Health Management and Informatics Alumni Organization's first Lifetime Achievement Award at the 2010 American College of Healthcare Executives Annual Congress. He has published journal articles in a variety of publications, including the *New England Journal of Medicine* and *Health Affairs*.

1970s

Kathleen R. Flaherty (Weinberg '73, MS '75, PhD '79), former chief marketing officer of AT&T Corporation, was appointed an independent nonexecutive director of Yell Group.

Josh Jacobs ('77) of Chicago is chair of orthopedic surgery at Rush University Medical Center. He was elected president of the US Bone and Joint Decade, a national action network of a global campaign to improve the quality of life for people with musculoskeletal conditions.

Michael E. Friduss ('79) of Palo Alto, California, is a clinical associate professor in the head and neck surgery department at Stanford University. He received the department's clinical faculty teaching award for 2009.

1980s

Mike Kelly ('80) was named a senior member of the Association for Computing Machinery, the world's foremost educational and scientific computing organization. He runs Mike Kelly Consulting on Bainbridge Island, Washington.

Brad Smith ('81) of Sammamish, Washington, is the director of worldwide licensing and pricing at Microsoft, where he has worked for seven years.

George Ribarchik ('82), senior food scientist for Wacky Snacky Inc., received a "best green paper" award from the American Sustainability Society for his paper "Bioflavinoid Synthesis via Protein Derived Nano-Catalytic Reactions." Ribarchik is also employed by the US Forest Service as a part-time bush pilot.

Shai Simonson (MS '82, PhD '86) recently published the book *Rediscovering Mathematics: You Do the Math* through the Mathematical Association of America.

William Schonberg (MS '83, PhD '87), professor and chair of the civil, architectural, and environmental engineering department at Missouri University of Science and Technology, received the NASA Engineering and Safety Center Honor Award.

Steven D. R. Carnes ('84, Kellogg '89, MME '90) is a technology transfer consultant at Fuentek, an intellectual property and technology management consulting firm.

Yie-Hsin Hung ('84) was named CEO of alternative investments for New York Life Investments. He was formerly global head of strategic acquisitions and alliances for Morgan Stanley Investment Management.

William Kornegay Jr. ('85) was appointed senior vice president of supply management at Hilton Worldwide. He was previously senior vice president at Godiva Chocolatier.

Mark A. Moore ('86) was named senior vice president of engineering for ENXSUITE. Previously he was vice president for ScaleDB.

Christopher J. Sommers ('86) was promoted from senior vice president of business development to CEO of ThinkFire Inc., an intellectual property advisory and brokerage firm.

Clifford R. Perry III ('87) of Chicago is a partner with the law firm Laner Muchin. He was named one of the top attorneys in Illinois for 2010 by Illinois Super Lawyers. He has represented employers in state and federal courts in the United States and before numerous local, state, and federal administrative agencies.

Sigfrid A. Muller Jr. ('88) was named vice president of business development at Blue Cross and Blue Shield of Minnesota. She was previously vice president of marketing for mPay Gateway.

K. Sujata (PhD '89), director of programs for the Eleanor Foundation, was named president of the Chicago Foundation for Women.

Suk-Chung Yoon (MS '89, PhD '91), professor and chair of computer science at Widener University, was selected to join the 2010–11 class of the American Council on Education Fellows Program.

1990s

Henry (Hank) Marcy (PhD '90) has recently taken the position of senior vice president, product design and engineering, at Bissell Homecare Grand Rapids, Michigan.

Sizwe W. Mncwango ('90, MS '90), chairman of Proactive Health Solutions, was elected to the board of directors of Omnia Holdings.

Matthew Birkelund McCall (Kellogg '91, MEM '92, Kellogg '92) has seeded a new startup called Brighttag, which helps website operators police Internet marketers.

James Charles Brailean (PhD '93), chief executive office and cofounder of PacketVideo, was elected to the board of directors of Sonic Solutions.

Robin M. Vogel (MEM '93, Kellogg '93) joined Topco Associates as senior vice president of center store procurement.

Chris Cotropia ('96) of Richmond, Virginia, was tenured and promoted to full professor at the University of Richmond School of Law. His research focuses on intellectual property law.

David S. Muson ('96) was appointed vice president at investment bank Houlihan Lokey. He was formerly vice president in the corporate finance group at BNP Paribas.

Partha P. Ray ('96) was appointed a director on the medical devices team of Research Corporation Technologies, based in Tucson.

Srujesh Shah ('97) of Des Plaines, Illinois, is a founder of and consultant with Ethically Managed, a firm that provides an ethics hotline and training and other ethics services.

2000s

Edward S. Cholewa (MEM '01) was named department manager for the national power delivery program at HDR, an architectural, engineering, and consulting firm.

Douglas Heim ('02) received his PhD in mechanical engineering from the University of Wisconsin–Madison in February 2011. He is currently employed by Cummins in Columbus, Indiana, developing gaseous spark-ignited engines.

Ari Margolis ('02) is an assistant rabbi at Temple Beth Or in of Raleigh, North Carolina. He completed his rabbinical studies at Hebrew Union College in Los Angeles and was ordained a rabbi in May 2010. He writes, "Believe it or not, I still use my engineering problem-solving skill sets on a daily basis."

Christopher Ellison (PhD '05), assistant professor of chemical engineering at the University of Texas at Austin, is joining the technical advisory board of FibeRio Technology Corporation.

Sanjuana Jamie ('05), an embedded software engineer in the electronics systems sector of Northrop Grumman Corporation in Rolling Meadows, Illinois, was named most promising engineer or scientist (undergraduate degree) at the Hispanic Engineer National Achievement Awards.

Sara Hodges Owsley (MS '05, PhD '08), assistant professor of computer science at Pomona College in Claremont, California, is leading a research project to study web comment threads and, using software, determine when such threads cross the boundary between constructive and destructive. She received a 2010 Wig Distinguished Professor Award for Excellence in Teaching.

Hans Martin Roth (MEM '08, Kellogg '08), was named an associate in the Houston office of Russell Reynolds Associates, an executive search and assessment firm. He was previously at the Boston Consulting Group.

Kristin Jenise Vicari ('08) received an MS in chemical engineering practice from the Massachusetts Institute of Technology, where she will continue to pursue her doctorate in chemical engineering.

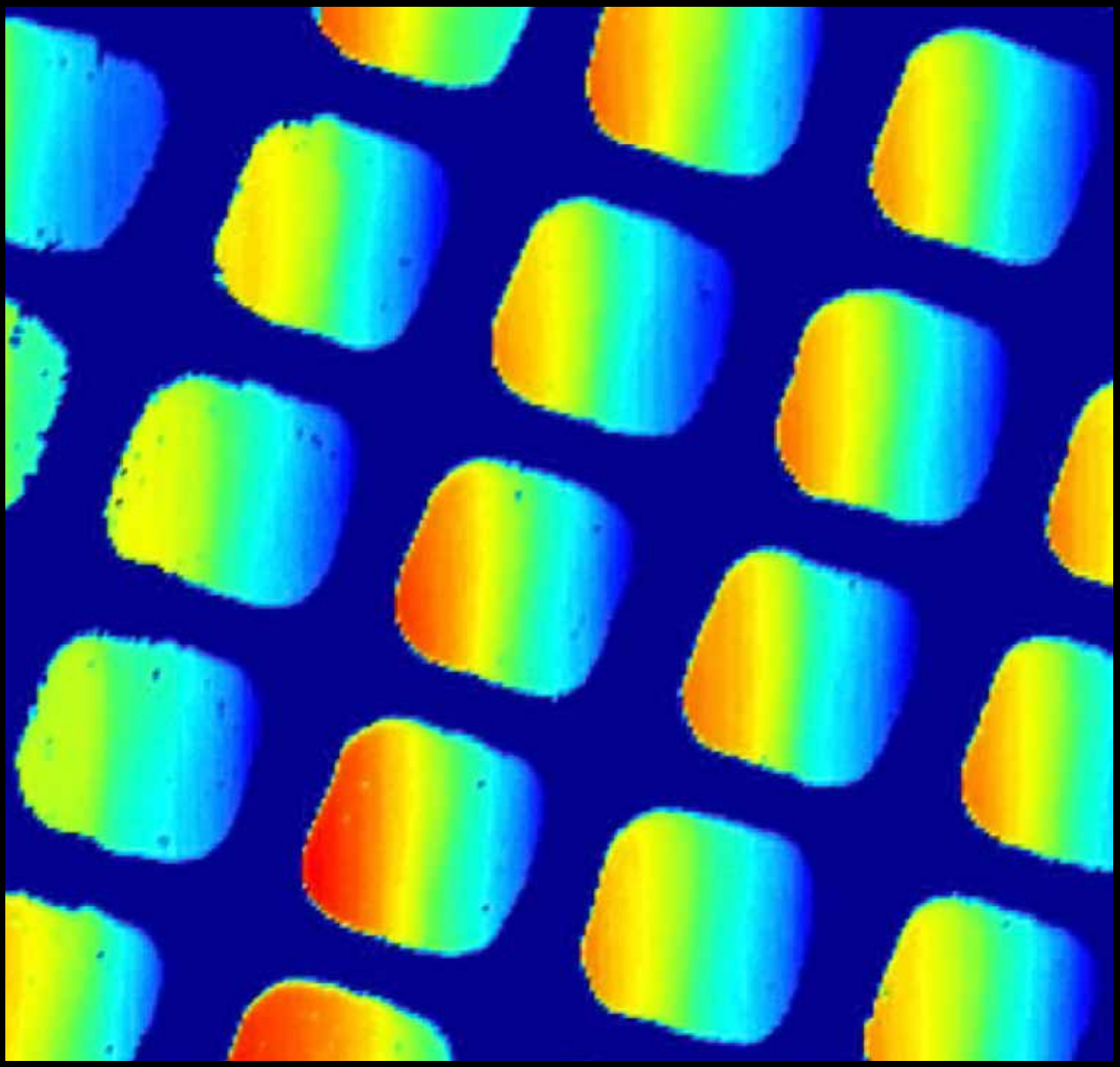
In memoriam

Robert F. Eyer '29
C. Harold Morris '34
Roger W. Robinson '35
Roy W. Kauffin '36
Chester W. Bland '40
John R. May '43
Donald R. Woods '43
Richard S. Jay '44
Chad B. Pierce '44
Einar J. Johnson '45
Lewis Roy Warmington '45
Robert D. Adams '46
Robert H. Kuhlmeier '46
David J. Lolly Jr. '46
Philip S. Lund '46
Russell L. Parker '46
C. Spencer Powell '46
Merle E. Dowd '47
Aubrey J. Greenberg '47
John W. Watson '47
John N. Bos '48
Donald M. Ross '48
Gerald W. Giles '49
Walter T. Miiller '49
Benjamin A. Schmetterer '49
Francis E. Smith '49
Clemens A. Storch Jr. '49
John W. Bowden '50
Jerome W. Finnigan '50
Edward D. Reynolds '50
Kenneth A. Rogers '51
Edward J. Campbell '52
Burnham Casterline '52
James B. Horne '52
Theodore H. Otterbacher '52
Arthur A. Hagstrom '53
William O. Holmes '53
Robert N. Sillars Jr. '53
Fred W. Gatter Jr. '54
David H. Drews '55
Salvatore V. Ferrera '56
Roy W. Hovinen '56
George M. Reynolds '57
Donn Fichter '58
James F. Ross, PhD '59
Gerald F. Brieske, PhD '60
Peter C. Appel '61
William L. Knight '61
Andrew B. Cvercko '62
Allan D. Stephens '63
Anthony C. Arko, PhD '65
Gerald W. Buckles '65
Herbert H. Wald '65
Robert H. Bryant '67
David W. Mineck '67
Christopher H. Edwards '73
William T. Gex '74
Richard A. Peterson '81
Donna L. Gilbert '82
Kevin W. Pruiett '83
Kenneth G. Hageman '86
Lt. Wade F. Wilkinson '86
William M. Gottliebson '88
Stephanie C. Otis '90
Anne M. Mayes '91

Editor's note: We inadvertently left "In memoriam" out of the fall 2010 issue of McCormick *magazine. Please visit magazine.mccormick.northwestern.edu to see the list.*

Send us your news!

Please e-mail your news to magazine@mccormick.northwestern.edu



the art of engineering

Research at McCormick pushes frontiers and crosses disciplines—and along the way it may produce images of significant aesthetic value. These images may suggest new questions, generate or reveal new information, convey new meaning, and generate new connections. Many—like the one shown here—can be considered pieces of art in their own right.

This image shows the electrical current within an organic photovoltaic cell at the nanometer scale. Using a specialized technique, atomic-force photovoltaic microscopy, researchers in the laboratory of Mark Hersam, professor of materials science and engineering, chemistry, and medicine, can characterize the behavior of photovoltaic cells. This understanding allows researchers to design more efficient materials for solar energy. Read more about Hersam's research on page 16.

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of Engineering and Applied Science
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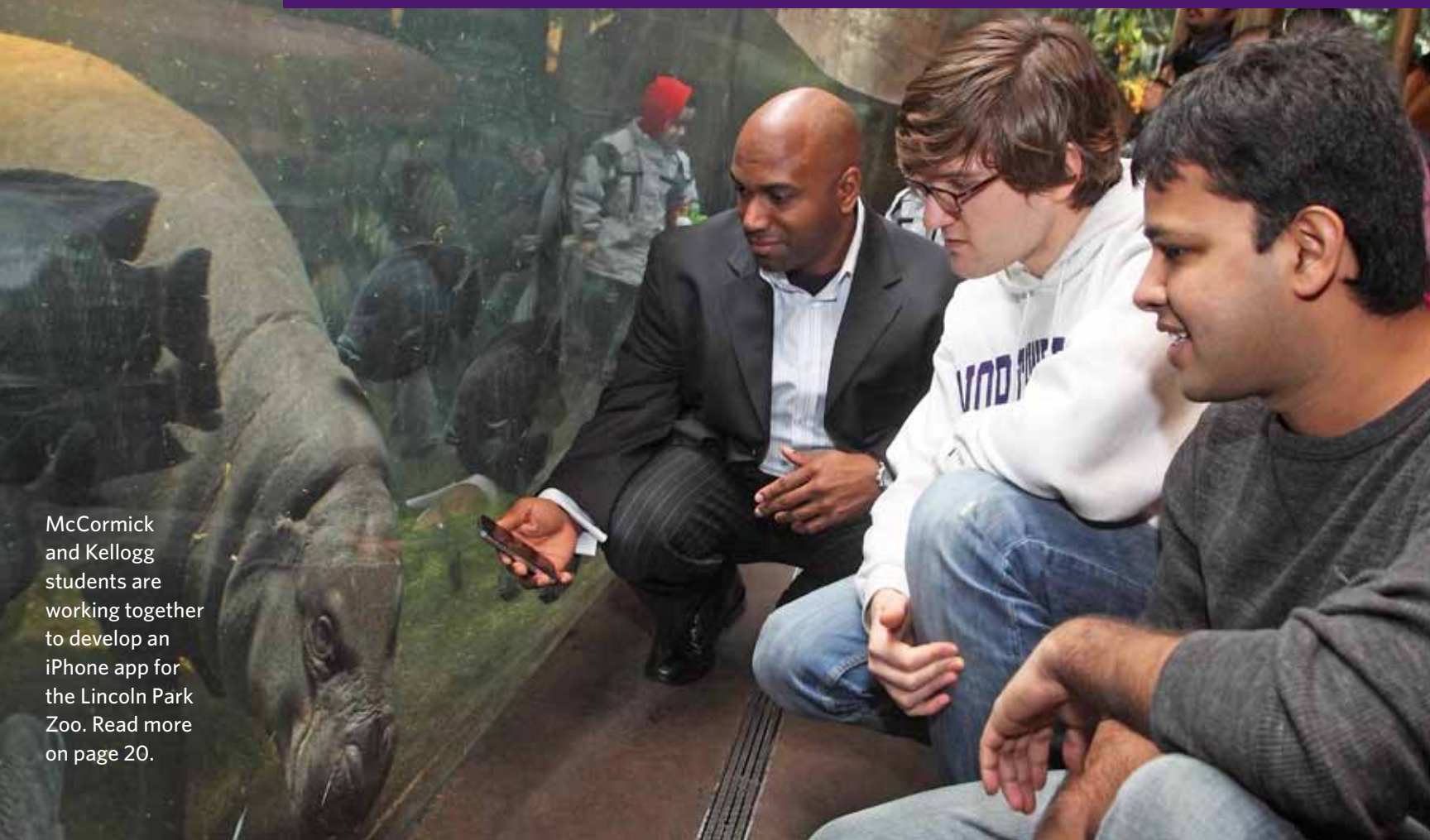

McCormick and Kellogg students are working together to develop an iPhone app for the Lincoln Park Zoo. Read more on page 20.