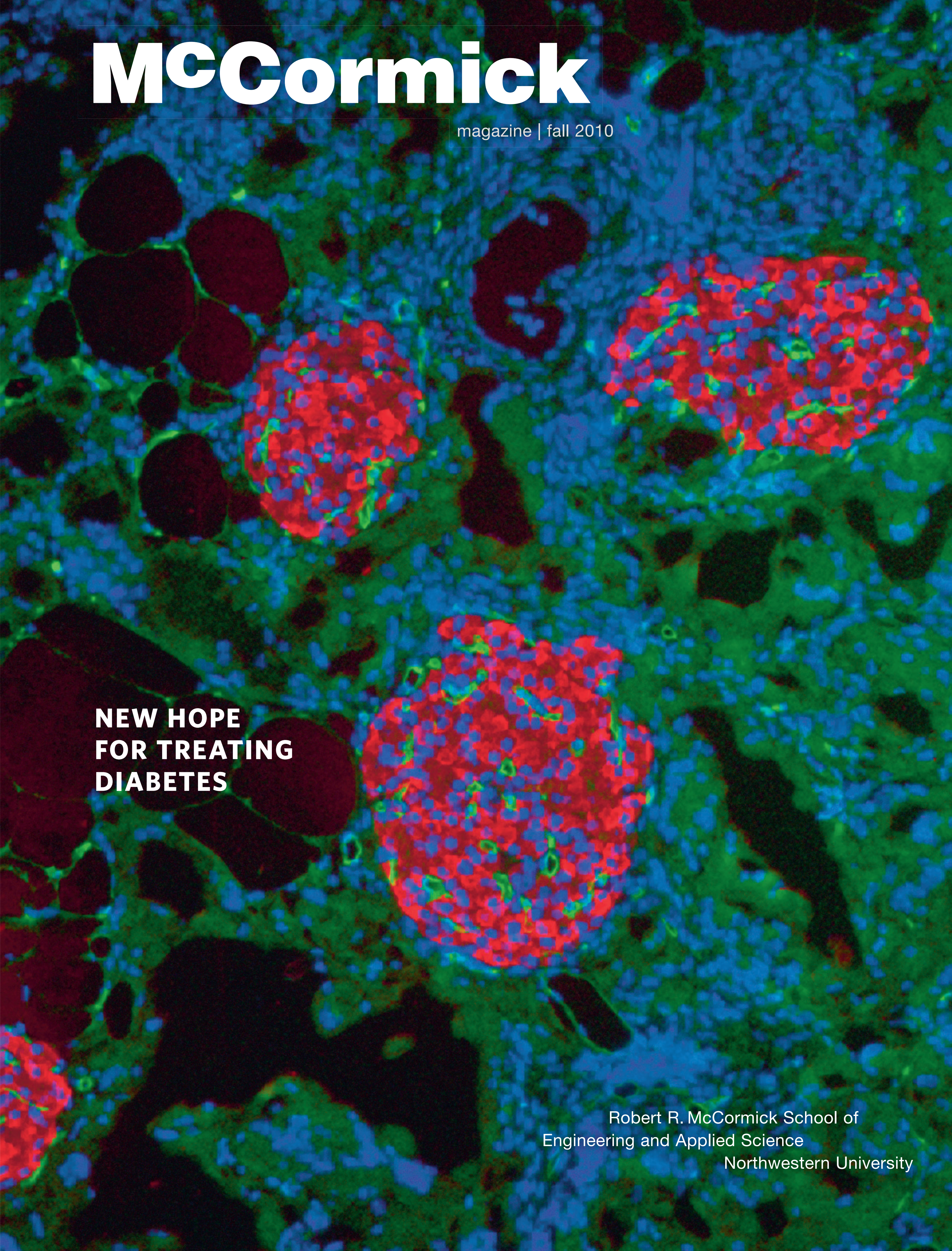
McCormick

magazine | fall 2010



NEW HOPE FOR TREATING DIABETES

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

FROM THE DEAN

Greetings from McCormick.

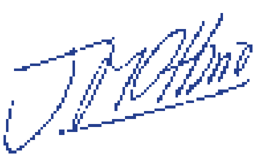
As we end our Centennial celebration, I'm pleased to have had the opportunity to meet so many of you at venues around the country. In events in Chicago, New York, Washington, DC, San Francisco, and Los Angeles, nearly 2,500 alumni, faculty, staff, students, and friends of McCormick joined us to celebrate 100 years of excellence in engineering at Northwestern. In this issue you'll see photos from our last two events, and you can visit the McCormick website to see many more.

The year was successful on many fronts, especially for our students: Undergraduates were recognized with Churchill, Goldwater, and Udall scholarships, and 14 graduate students were named NSF fellows. Even job placement looks remarkably strong, with only 5 percent of 2010 graduates reporting that they had yet to finalize their plans at graduation (this is the lowest since 1997). In this issue you'll read about students involved in design and research projects. These examples typify both analysis and creativity — a powerful combination. Whole-brain thinking is a skill that will help them throughout their careers.

Our faculty continue to grow successful research enterprises and leverage their expertise in new and creative ways. In our cover story, you can read about how Samuel I. Stupp in materials science and engineering, Phillip Messersmith in biomedical engineering, and Lonnie Shea in chemical and biological engineering are working with collaborators at the Feinberg School of Medicine to explore new treatments for diabetes. Aggelos Katsaggelos and Sotirios Tsaftaris in electrical engineering and computer science used their algorithms to help unveil an earlier draft of a famous Henri Matisse painting. Karen Smilowitz and Irina Dolinskaya in industrial engineering and management sciences are using their logistics research to help optimize disaster relief.

As we begin the 2010–11 school year, we look forward to another 100 years of excellence. I hope you will join us on this journey.

As always, I welcome your feedback.



Julio M. Ottino, Dean | October 2010

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: Immunofluorescence of syngeneic pancreatic islets transplanted on polymer scaffolds in the fat pad of a mouse. Insulin (red), vasculature (green), and nuclear (blue) staining demonstrates islet engraftment 14 days after implantation. *Image from the lab of Lonnie* Shea. See story on pages 6–11.

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 Produced by University Relations. 10-10/27M/TF-VL/11717

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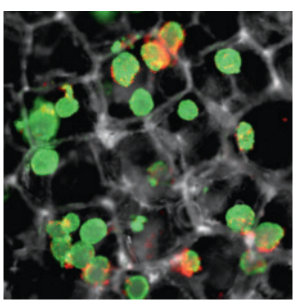

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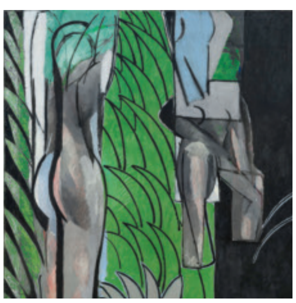

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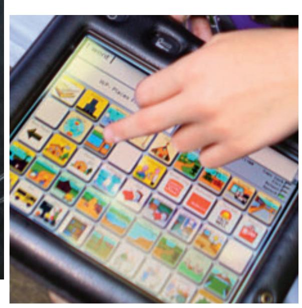

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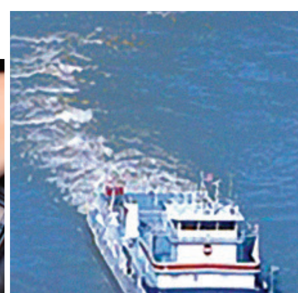

McCormick news

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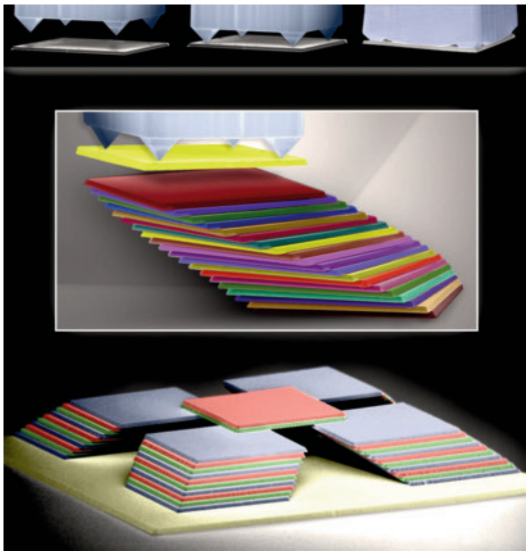
GECKOS INSPIRE NEW ELECTRONIC PRINTING METHOD



Geckos are masters of sticking to surfaces of all kinds—and easily unsticking themselves, too. Inspired by these lizards, a team of engineers has developed a reversible adhesion method for printing electronics on a variety of tricky surfaces such as clothes, plastic, and leather.

Researchers from Northwestern and the University of Illinois at Urbana-Champaign (UIUC) designed a square polymer stamp that allows them to vary its adhesion strength. The stamp can pick up an array of electronic devices from a silicon surface and move and print them on a curved surface. The research was published by the *Proceedings of the National Academy of Sciences (PNAS)*.

"Our work proposes a very robust method to transfer and print electronics on complex surfaces," said **Yonggang Huang**, Joseph Cummings Professor of Civil and Environmental Engineering and Mechanical Engineering at the McCormick School. Huang, co-corresponding author of the *PNAS* paper, led the theory and design work at Northwestern. John Rogers at UIUC led the experimental and fabrication work and is a co-corresponding author of the paper.

Key to the stamp are four pyramid-shaped tips on the bottom, one in each corner. They mimic the micro- and nanofilaments on the gecko's foot, which the animal uses to control adhesion by increasing or decreasing contact area with a surface. Pressing the stamp against electronics causes the tips to collapse against the stamp's body, maximizing the contact area between the stamp and the electronics and creating adhesion. The electronics are picked up, and, with the force removed, the soft tips snap back to their original shape. The electronics now are held in place by just the four tips — a small contact area. This allows the electronics to be easily transferred to a new surface. "Design of the pyramid tips is very important," Huang said. "The tips have to be the right height. If the tips are too large, they can't pick up the target. If the tips are too small, they won't bounce back to their shape."

The researchers found the changes in contact area allow the stamp's adhesion strength to vary by 1,000 times. They also demonstrated their method can print layers of electronics, enabling the development of a variety of complex devices.

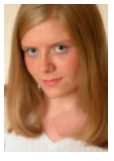
The National Science Foundation and the Department of Energy supported the work.

McCORMICK SCHOLARSHIPS

McCormick students were extremely successful in receiving fellowships and scholarships in 2009–10. Several undergraduates received high-profile competitive scholarships, and 14 graduate students received National Science Foundation fellowships — the most ever for McCormick.

"These scholarships are extremely competitive," says Stephen Carr, associate dean for undergraduate engineering. "Our students have been successful in pursuing and receiving national and international accolades that help them push their education and research to the top level."

Kelsey Stoerzinger (materials science and engineering '10) was awarded a Churchill Scholarship to pursue graduate studies at the University of Cambridge. The scholarship provides a year of support for a postgraduate degree in engineering, mathematics, or the sciences at Cambridge. Stoerzinger will be working toward a research-based master of philosophy degree in physics.



Samantha Dale Strasser (biomedical engineering, applied mathematics '11) was one of four Northwestern students to receive a Barry M. Goldwater Scholarship, which encourages outstanding students to pursue careers in mathematics, the natural sciences, or engineering and to foster excellence in those fields. Strasser hopes to obtain her PhD in biomedical engineering.

Isabelle Ji, a senior working toward a combined bachelor's degree in environmental engineering and a master's in chemical engineering, was awarded a Udall Scholarship, given to students committed to careers related to the environment, tribal public policy, or Native American health care. Ji is interested in a career in business strategies for sustainable development. On campus she leads education and outreach for Engineers for a Sustainable World.

Other McCormick students who earned scholarships and fellowships include the following:

- **Phillip Brunner,** a graduate student in materials science and engineering, and **Lisa Felberg** (chemical engineering '11) received DAAD German Research grants.
- **Mark Ison,** a graduate student in electrical engineering and computer science, received the Congress-Bundestag Youth Exchange for Young Professionals and Erasmus Mundus scholarships.
- **John Sheppard** (biomedical engineering '10) received an NIH-Oxford-Cambridge scholarship.
- **Aaron Young,** a graduate student in biomedical engineering, received the National Defense Science and Engineering Graduate fellowship.
- **Danielle Proffit,** graduate student in materials science and engineering, received the Department of Energy Graduate fellowship.
- **Gregory McGlynn** (computer science '11) received the NASA Aeronautics Scholarship.
- 14 graduate students received National Science Foundation research fellowships.

PROFESSORS RECEIVE $39 MILLION IN STIMULUS FUNDING

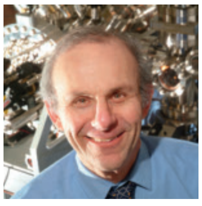
McCormick School professors are part of research projects that have received more than $39 million in funding from the American Recovery and Reinvestment Act. The act, passed by Congress in February 2009, allocated billions for scientific research. Professors in every department at McCormick have applied for and received awards that range from $50,000 to more than $19 million.

"The success of McCormick's research awards is a consequence of our commitment to excellence in research and education," said Julio M. Ottino, dean of McCormick. "Our professors are at the leading edge of science and technology in preparing students to address the most challenging global problems. We are poised to make a difference."

The largest grant — $19 million — funds the new Non-Equilibrium Energy Research Center led by **Bartosz Grzybowski,** the Kenneth Burgess Professor of Physical Chemistry and Chemical Systems Engineering. Its focus is to synthesize, characterize, and understand new classes of materials under conditions far from equilibrium that are relevant to solar energy conversion, catalysis, and storage of electricity and hydrogen.

"Many of these awards are research projects that cross disciplines and schools," says Rich Lueptow, senior associate dean for operations and research at McCormick. "This sort of effort is part of the culture at McCormick, and it is essential to the innovation our country needs in this economy."

TWO ELECTED TO THE AMERICAN ACADEMY OF ARTS AND SCIENCES



Two McCormick professors in materials science and engineering — **Monica Olvera de la Cruz** and **David Seidman** — have been elected to the American Academy of Arts and Sciences, one of the nation's oldest and most prestigious honorary societies and independent policy research centers.

Seidman is a Walter P. Murphy Professor of Materials Science and Engineering. His research aims to understand physical phenomena in a wide range of material systems on an atomic scale. He and his research group are studying aluminum-, nickel-, and iron-based alloys for possible high-temperature and structural applications and metal silicide/silicon reactions pertinent to solid-state devices.

Olvera de la Cruz is the Lawyer Taylor Professor of Material Science and Engineering and professor of chemical and biological engineering and of chemistry. She has developed theoretical models to determine the thermodynamics, statistics, and dynamics of macromolecules in complex environments, including multicomponent solutions of heterogeneous synthetic and biological molecules.

Olvera de la Cruz was named by the Department of Defense as a fellow in its National Security Science and Engineering Faculty Fellowship program, one of only 11 faculty scientists and engineers from across the nation in the program's 2010 class. She will receive up to $4.25 million of support for up to five years for her research project "Paradigms for Emergence of Shape and Function in Biomolecular Electrolytes for the Design of Biomimetic Materials."

Seidman and Olvera de la Cruz are 2 of the 229 leaders in the sciences, the social sciences, the humanities, the arts, business, and public affairs who were elected to AAAS this year. Joining them were three other faculty members from Northwestern, including University President Morton Schapiro.

DETECTING COLON CANCER IN WOMEN

A team led by **Vadim Backman,** professor of biomedical engineering, found that combining novel optical technologies with a common colon cancer screening test may allow doctors to more accurately detect the presence of colon cancer, particularly in women. The study, done in partnership with colleagues at NorthShore University HealthSystem, combined a polarization-gating optical probe alongside traditional flexible sigmoidoscopy to measure the early increase in blood supply in rectal tissue as a marker for colon cancer. The results were published in the journal *Cancer Prevention Research.*

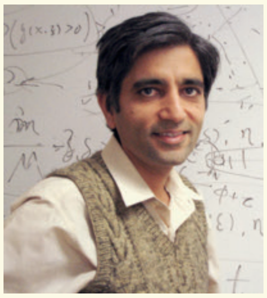
A flexible sigmoidoscopy examines the lower third of the colon for cancer. It's quick and affordable, can be conducted by a primary care physician, and requires simpler bowel preparation than that of a colonoscopy. However, the test isn't widely used for colon cancer screening because it examines only the lower third of the colon.

Women are more likely than men to have cancerous lesions in the proximal colon, a section of the colon not examined during flexible sigmoidoscopy. By itself that method detected only a third of colon cancers in women, according to previous studies.

The Northwestern researchers combined the flexible sigmoidoscopy with an optic probe that measures how light scatters through tissue and detects subtle changes in the tissue that can indicate the presence of cancer. The technology makes use of a biological phenomenon known as the "field effect," a hypothesis that suggests the genetic and environmental milieu that results in a neoplastic lesion in one area of an organ should be detectable throughout the organ and even in neighboring tissue. The combined technique identified with 100 percent accuracy each person who had a neoplasia in the proximal colon. Researchers found that the early increase in blood supply was a particularly robust marker for proximal neoplasia in women.

This result provides hope that the technique could provide a mechanism to improve discrepancies in the accuracy of colon cancer screening between men and women.

NEW YORK FALLS SHORT IN HOMELAND SECURITY FUNDING



New budget allocation models developed by **Sanjay Mehrotra,** professor of industrial engineering and management sciences, suggest that New York City appears underfunded for protection against terrorist threats. The study also shows Chicago as underfunded, while Los Angeles appears overfunded.

Mehrotra and his team analyzed budgets for five fiscal years (2005–09) for 10 major US urban areas under a variety of terrorist-attack scenarios. The researchers found the funding received by New York in 2009 was around 30 percent of the total money allocated by the Department of Homeland Security to the 10 areas. According to the Northwestern models, the funding should have ranged between 33 and 49 percent. This would translate to a net increase of anywhere between $15 million and $92 million above the actual level of funding New York received in 2009.

McCormick IN THE MEDIA

RATING AND RANKING AND SOCCER PLAYERS

Luis Amaral, professor of chemical and biological engineering (below), combined his love of soccer with his research team's computational skills to measure and rank the success of soccer players based on an objective measure of performance instead of subjective opinion. The results were published in *PLoS ONE,* a journal published by the Public Library of Science. Amaral and his team were able to objectively rank the performances of all the players in the 2008 European Cup tournament. Their results closely matched the consensus of sports reporters who covered the matches as well as the team of experts, coaches, and managers that chose players for the "best of" tournament teams.

To find a quantitative way to rank players, graduate student **Josh Waitzman,** a coauthor of the paper, first wrote software to pull play-by-play statistical information from the 2008 European Cup website. This type of extensive statistical information is usually only gathered for important matches, Amaral says. Then Amaral and Jordi Duch, the paper's first author and a faculty member at Universitat Rovira I Virgili in Spain, used the data to quantify the performance of players by generalizing methods from social network analysis. They mapped out the flow of the soccer ball between players in the network and shooting information and analyzed the results.

"We looked at the way in which the ball can travel and finish on a shot," says Amaral, who also is a member of the Northwestern Institute on Complex Systems and an Early Career Scientist with the Howard Hughes Medical Institute. "The more ways a ball can travel and finish on a shot, the better that team is. And, the more times the ball goes through a given player to finish in a shot, the better that player performed."

This research has been featured in several national media outlets, including MSNBC, the *Washington Post, Scientific American,* and *Forbes.*

OIL, MAZES, AND CANCER

Bartosz Grzybowski, the Kenneth Burgess Professor of Physical Chemistry and Chemical Systems Engineering, was interviewed on the BBC radio program *Material World* regarding his research that shows how droplets of oil can make their way through complex mazes. Gryzbowski created a system in which the droplets were powered by a combination of acid/base chemistry and surface-tension effects. When subject to a pH gradient within a maze, the droplets moved toward regions of low pH and found the shortest possible path through the maze. The technique could have implications in cancer therapy, as cancers are more acidic than the rest of the body. Researchers might design drugs to follow the pH gradient to cancer cells.

Published in January in the *Journal of the American Chemical Society,* the research has been featured in *Science, Nature,* and *Popular Science,* among other publications.

A NEW HOME FOR THE CENTER FOR LEADERSHIP

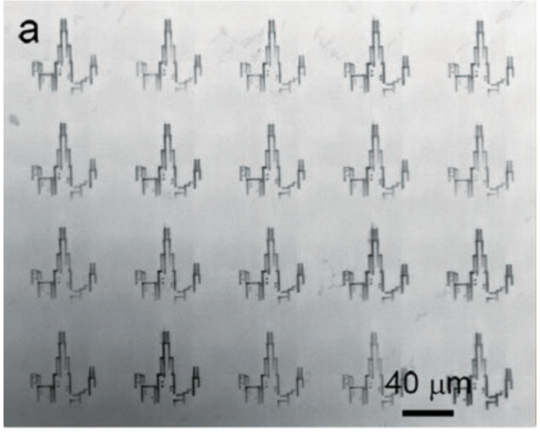
The Center for Leadership at Northwestern has a new academic home at the McCormick School. McCormick will host the center's academic offerings, serve as a springboard for the center's connections with the University community, and provide faculty appointments to its leadership team.

"We're excited to join McCormick because we think that leadership will complement the other offerings of the school," says **Adam Goodman,** director of the Center for Leadership. "McCormick students will be called upon to be leaders in their careers, so it's important for the school to introduce them to the concepts of effective leadership throughout their education."

The Center for Leadership started in 1990 as the Undergraduate Leadership Program. For 20 years the program provided a popular undergraduate certificate program in leadership, and more than 2,500 students have participated in the program.

"The Center for Leadership is an excellent addition to the curricular and extracurricular activities offered to our students," says Dean Julio M. Ottino. "Combined with other new initiatives at McCormick — such as the Segal Design Institute and the Farley Center for Entrepreneurship — we are building offerings to create whole-brained engineers. Our students emerge with deep technical knowledge, which is at the heart of engineering, but we must also instill leadership, entrepreneurship, and design skills into their thinking in order to prepare them to have maximum impact on the world."

PENS PROMISE LOW-COST RAPID NANOFABRICATION



A Northwestern research team has drawn 15,000 identical Chicago skylines with tiny beams of light using an innovative nanofabrication technology called beam-pen lithography. The team was led by **Chad A. Mirkin,** professor of biomedical engineering at McCormick, the George B. Rathmann Professor of Chemistry in the Weinberg College of Arts and Sciences, and director of Northwestern's International Institute for Nanotechnology. Details of the method were published in the journal *Nature Nanotechnology.*

Researchers simultaneously patterned 15,000 replicas of the Chicago skyline over a few square centimeters of space using 15,000 tiny pens. Each skyline pattern was made up of 182 dots, with each dot approximately 500 nanometers in diameter — the diameter of each pen tip. The time of light exposure for each dot was 20 seconds, with the entire process taking about a half an hour. The method results in structures as small as 150 nanometers, though refinements of the pen architecture likely will increase resolution to below 100 nanometers. Conventional nanopatterning technologies, such as electron-beam lithography, can make similarly small structures but are inherently low throughput and cannot do large-area nanofabrication.

Beam-pen lithography could lead to the development of a sort of desktop printer for nanofabrication, giving individual researchers a great deal of control over their work. The method offers a means to rapidly and inexpensively make and prototype circuits, optoelectronics, and medical diagnostics and promises many other applications in the electronics, photonics, and life sciences industries.

NANOFIBER "NOODLE GEL" PROMISES BETTER TISSUE REGENERATION

A Northwestern team is the first to demonstrate a method that delivers cells in the same alignment as the cells found in tissues, a technique that could jumpstart new growth and healing. The findings were published as the cover story in the July issue of the journal *Nature Materials.* The paper's senior author was **Samuel I. Stupp,** Board of Trustees Professor of Materials Science and Engineering, Chemistry, and Medicine and director of the Institute for Bionanotechnology in Medicine.

The researchers produced centimeter-long, noodle-shaped strings of nanofibers containing living cells aligned in linear fashion.

These gel-like strings are flexible, biodegradable, and can be made into different lengths and widths. They could be surgically placed on damaged tissue, where they would adhere naturally.

To create the noodle gel, Stupp and his team start with aggregates of specially designed peptide amphiphile molecules in water. Heating the solution causes the molecules to emerge as sheets suspended in water. When cooled, the sheets break into bundles of fibers, forming an unusual liquid crystal. The researchers then mix cells into the liquid crystal and, using a pipette, draw it by hand across a salt solution, causing the liquid crystal to gel immediately. The result is like a piece of cooked spaghetti composed of aligned nanofibers with huge populations of encapsulated cells.

Stupp is collaborating with other researchers on studies using the noodle gel for stem-cell delivery. One project focuses on the use of the aligned structures as highways to divert stem cells from parts of the brain where they are abundant to others where they might be needed to cure diseases, such as Parkinson's.

Donald N. Frey, 86, professor of industrial engineering and management sciences, died in March. At McCormick he taught courses on innovation, entrepreneurship, and information systems; he also taught first-year engineers in the Engineering Design and Communication sequence — "to keep my foot in reality," he said. Frey also mentored doctoral students.

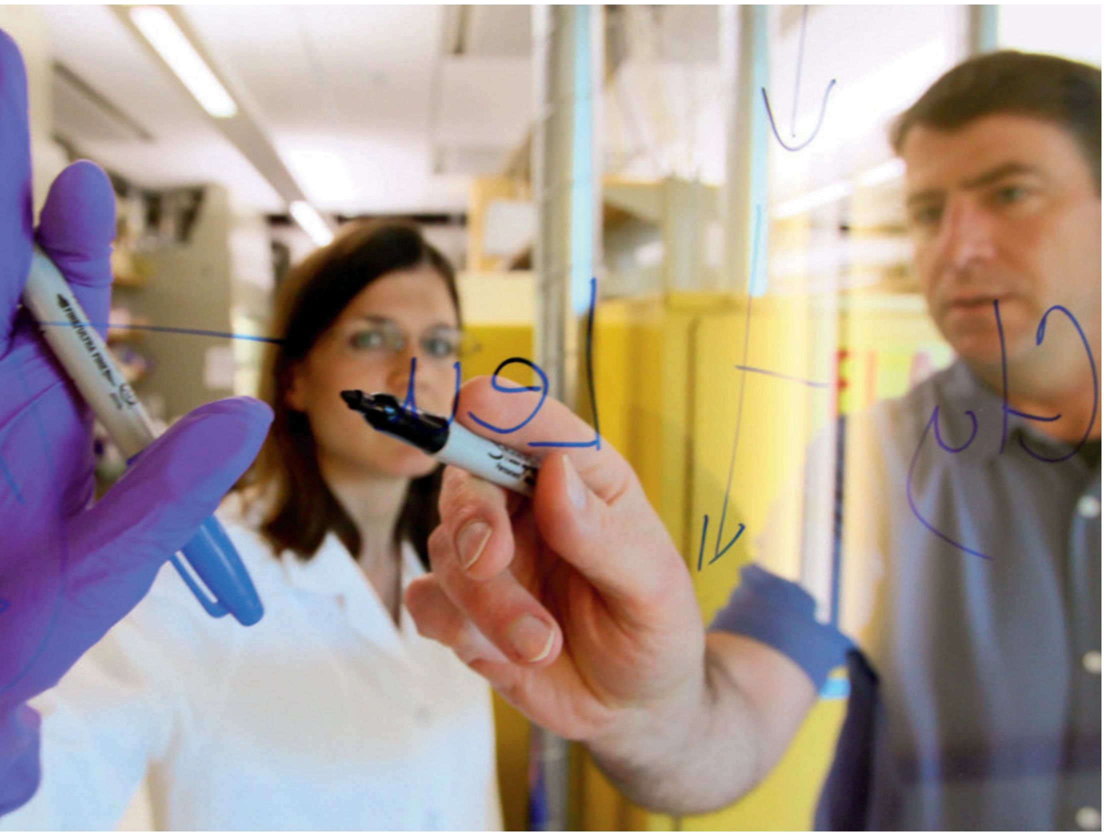
Frey enjoyed a long and illustrious industrial career — with Ford Motor Company, General Cable Corporation, and Bell & Howell Company — before joining Northwestern in 1988. Along with others, he came up with the concept and design of the Ford Mustang, a car that became an American icon. Frey was an elected member of the National Academy of Engineering and received the National Medal of Technology from President George H. W. Bush in 1990.

In 2001 Frey established the annual Margaret and Muir Frey Prize at McCormick. Named for his late parents, the prize recognized design creativity in the best senior capstone projects — projects that are designed by a student or team of students and are related to known problems or credible new products or processes.

Diabetes dilemma

Fluorescence image of mouse pancreatic islets. The live islets are green; the dead ones are red. The islets are seeded on a microporous polymer scaffold prior to transplantation. ***Image from the lab of Lonnie Shea.***

RESEARCHERS LOOK FOR WAYS TO MAKE ISLET TRANSPLANTATION VIABLE



Phil Messersmith and graduate student Carrie Brubaker discuss adhesives that help islets survive in donors. *Photo by Andrew Campbell.*

For the more than 23 million diabetics in the United States, disease management can range from cumbersome to critical.

For many of those with type 2 diabetes, the disease often can be managed with diet and exercise. For type 1 diabetics, the disease can be managed with daily injections of insulin.

But there are complications related to manual monitoring of blood glucose — some as severe as blindness, kidney damage, and lower-limb amputation. And there are people whose bodies cannot handle daily injections of insulin. Annual medical costs for diabetes are estimated to be $116 billion, and according to the National Institutes of Health, more than 1.5 million new cases of diabetes are diagnosed each year.

So researchers continue to search for alternatives for managing blood glucose. Within the past decade, a new option has emerged: islet transplantation. Islets are clusters of cells from the pancreas that include beta cells, which regulate blood glucose levels. Though the cause of type 1 diabetes is unknown, researchers do know that a diabetic's own immune system mistakenly destroys the islet cells in the pancreas. Researchers also know that it's possible to take working beta cells from a donor and transplant them into a diabetic. Attempts have shown that this procedure essentially cures the diabetes; injections of insulin are no longer needed.

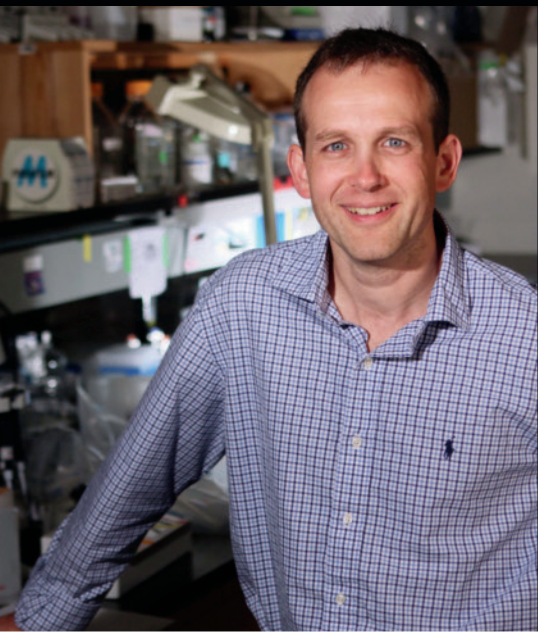
There are drawbacks, however. The patient must take immunosuppressant drugs to prevent the body from rejecting the cells, and the beta cells tend to stop working after only a couple of years.

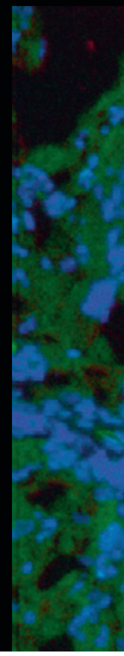
Yet there is hope. Several Northwestern researchers are working on different ways to make islet transplantation more effective. What if, for example, new materials could help protect the islets and integrate them into the body? Under the umbrella of the Institute for Bionanotechnology in Medicine (IBNAM), three McCormick faculty members are working with professors and surgeons at the Feinberg School of Medicine on three different approaches to the islet transplantation dilemma.

How to make islets survive

Islet transplantation has been around only for about a decade, and only a handful of hospitals across the country perform the procedure. The most popular location for transplanting the cells is the liver because it has many blood vessels that give the islets the nutrients they need to grow.

In 2006 the Collaborative Islet Transplant Registry reported that two-thirds of the 225 patients who received islet transplants between 1999 and 2005 achieved "insulin independence" after transplantation. But six months after receiving the last islets, only half of recipients no





longer needed insulin, and at the two-year mark it dropped to a third.

No one really knows why the islets fail: maybe they aren't getting enough nutrients, or maybe they are attacked by the recipient's immune system. So researchers are trying several methods to try to improve the success of the transplanted islets. One approach involves using an adhesive to stick the islets to the liver.

Enter Phil Messersmith, who knows how to get things to stick together. Several years ago Messersmith, professor of biomedical engineering and of materials science and engineering, and his group created a nanoadhesive called Geckel that fused a gecko's dry adhesion with a mussel's wet adhesive properties. He and his group also have developed synthetic polymers that mimic the composition and properties of the adhesive proteins that mussels use. "It's a very good glue to use in wet conditions," he says.

About five years ago Messersmith began to collaborate with Lonnie Shea, professor of chemical and biological engineering; Samuel I. Stupp, the Board of Trustees Professor of Materials Science and Engineering, Chemistry, and Medicine and director of IBNAM; and Dixon Kaufman, professor of surgery, director of the Pancreas and Islet Transplantation Programs of Northwestern Memorial Hospital, and a key collaborator at Feinberg. "We all got together with the intent of offering a unified, multifaceted approach to the treatment of diabetes," Messersmith says.

Messersmith thought he could use his mussel-inspired adhesive to stick islets to a layer of fat. That way surgeons wouldn't have to cut an organ, avoiding a blood inflammatory response that can contribute to islet failure. "It's an easier approach to transplanting," he says.

Messersmith tested his adhesive in mice in a procedure using syringes to place the islets on the tissue and then to apply the adhesive. The adhesive bonded within a minute and held the islets in place for up to four months. He found that the mice's blood glucose dropped to a normal range within a week after implantation. The group published a paper on the results earlier this year, and Messersmith would like to continue testing the procedure in mice to better understand the immune response to the islets.

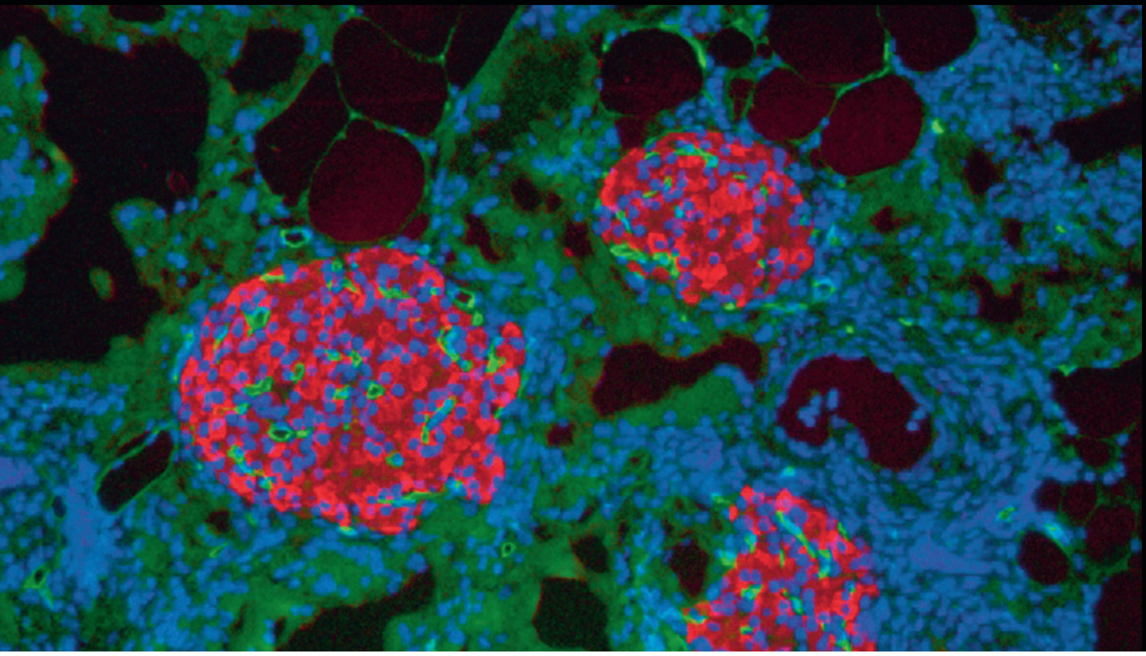
Though it's just one of several areas of research pursued in his lab, Messersmith hopes to continue this study to understand the immune response to his adhesive. "Increasing the options available for islet transplants would be a significant accomplishment," he says.

Building a sponge-like home for islets

Lonnie Shea takes a different approach. He is trying to create a tiny home for islets as they become part of their new body. "Typically researchers have tried to isolate islets from the immune system to help them survive," he says. "Islets occupy 1 percent of the mass of the pancreas but get 10 to 15 percent of the blood supply. If you're isolating islets from the immune system, you're not allowing blood vessels to access them."

Shea's group creates tiny structures called scaffolds out of a biodegradable polymer — the same material from which biodegradable sutures are made — and shapes them into a sponge. Each pore in the sponge is about 250 to 400 microns across and holds one or two islets, resulting in about 75 islets per sponge (normal mice pancreases have about 200 islets). Surgeons can then implant this sponge into the body. This technique, Shea says, gives surgeons an easy-to-use material, keeps the islets from aggregating (so they don't compete for nutrients), and allows blood vessels to grow through the scaffold and into the islets. Shea also puts a coating of extracellular matrix proteins around the scaffold that makes the islets easier to graft onto an organ; islets in the pancreas are normally surrounded by a fibrous matrix. "We're trying to deliver a minimal mass of islets and have them engrafted for a long time," he says.

Shea and his group have tested the scaffold in the fat pad of a mouse — the equivalent of the omentum (a layer of fat around the stomach) in humans. The results showed that blood vessels grow through the scaffold, and the scaffold itself degrades in 100 days. The islets continued working in the mouse for 300 days. "That's a large portion of the lifespan of the mouse," Shea says. "We're optimistic." Shea and his group have begun testing the scaffolds in pigs and primates. Early results from these ongoing studies



Opposite, from left: Lonnie Shea, Phil Messersmith, and Sam Stupp. ***Photos by Andrew Campbell.***
Left: Immunofluorescence of syngeneic pancreatic islets transplanted on polymer scaffolds in the fat pad of a mouse. Insulin (red), vasculature (green), and nuclear (blue) staining demonstrate islet engraftment 14 days after implantation. ***Image from the lab of Lonnie Shea.***

have been encouraging.

Immune response to the islets is still an issue. Shea has been collaborating with Steve Miller, professor of microbiology-immunology at Feinberg, to develop strategies for inducing tolerance by coupling antigens from donor cells with islets, reducing attacks from the recipient's immune system. Shea hopes to create synthetic particles that would mimic these strategies to induce tolerance from the immune system.

Shea also collaborates with Feinberg's Dixon Kaufman and Bill Lowe, an associate professor of medicine, an expert on the genetics of diabetes and islet cells and another collaborator of many engineers. "I think the collaboration is great," Shea says. "No one person has solutions to all aspects of this problem. The materials we have are platforms for targeting the various barriers to engraftment and function."

Shea eventually hopes to be able to test his scaffold in diabetic humans who cannot have islets transplanted into their livers. "I'm hoping it can be a cure for type 1 diabetes," he says. "I am fortunate to have three healthy children. I hope our research can one day end the need for any children and their parents to be burdened by the constant strain of insulin regulation and the associated impact to the quality of life."

> "Diabetes is clearly one of the main targets of regenerative medicine."
> SAM STUPP

Nanostructures that grow blood vessels

Sam Stupp is well known for his research on molecular self-assembly strategies for regenerative medicine. Molecular self-assembly is the assembly of molecules without guidance or management from an outside source. This occurs naturally in many biological systems, and researchers have begun to imitate the process to create tiny nanostructures that are programmed for certain functions. Stupp has used this technique to develop novel materials to promote regeneration in the central nervous system, which could impact therapies for spinal cord injury and Parkinson's disease, and he has developed new materials for the regeneration of bone, cartilage, and blood vessels.

The growth of blood vessels is a major component of Stupp's work, since regenerating tissue requires new blood vessels to provide nutrients to the cells. In 2004 Stupp led the charge to create a National Institutes of Health–funded bioengineering research partnership with Shea, Messersmith, Kaufman, and others to explore new solutions for regeneration of the central nervous system and cell-replacement therapies for diabetic patients. "Diabetes is clearly one of the main targets of regenerative medicine," Stupp says. "We reasoned that growth of blood vessels should be a major focus."

Stupp is working to improve the outcome of islet transplantation by using materials that promote the formation of blood vessels in transplant sites. He and his group have created self-assembling bioactive nanofibers that are formed by an interaction between heparin and peptide molecules. The proteins that signal cells to make new blood vessels grow have a specific affinity for heparin.

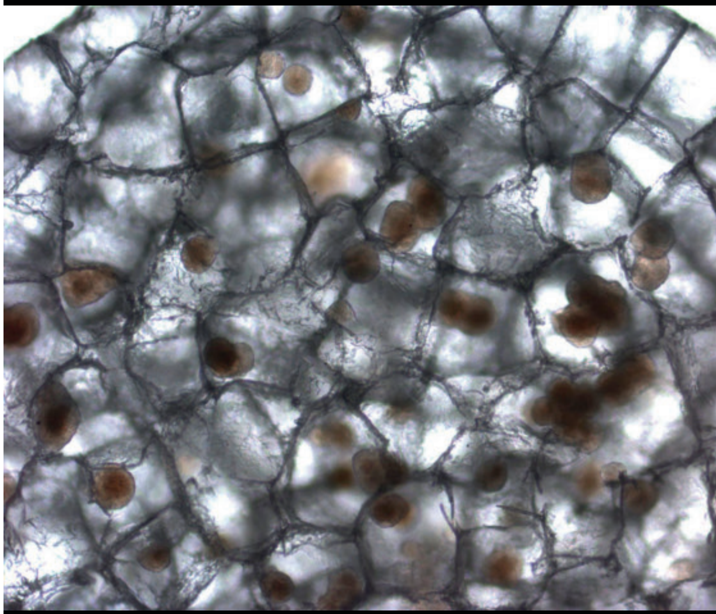
"Our nanofibers interact with those proteins, capture them, and even position them in the right orientation so that they can signal the cells and start the process of making new blood vessels," Stupp says. When endothelial cells (the cells on the interior of blood vessels) get the signal from the proteins, they begin to proliferate and create tube-shaped structures — the genesis of blood vessels.

The researchers found that, when tested in mice, the nanostructures indeed promoted blood vessel growth around the transplanted islets in vivo and enhanced the cure rate of diabetic mice that received the islets. That spurred Stupp to go a step further and actually introduce the nanostructure inside the islets themselves after they had been isolated and before they were implanted. "That way blood vessels can sprout from the islets themselves," he says.

Though this technique has just been tested in vitro, the positive results already have Stupp planning for the next step of testing these pretreated islets in transplantationl models. "The McCormick-Feinberg axis is critical to


Tissue-Tek

Left: Sam Stupp with members of his lab in the Institute for Bionanotechnology in Medicine. *Photo by Andrew Campbell.* Near right: Bright-field image of mouse pancreatic islets seeded on a microporous polymer scaffold prior to transplantation. Far right: Insulin staining (brown) of a pancreatic islet transplant on a microporous polymer scaffold in pigs. Staining demonstrates significant islet survival. *Images from the lab of Lonnie Shea.*



this work," Stupp says. "It would have been impossible to do this work at McCormick in isolation. One of the missions of IBNAM is to promote research collaborations, and this collaboration has been very successful."

"We want to get people who were diabetic insulin-free."
DIXON KAUFMAN

Bringing the lab to the bedside

When describing their research and their approaches, all McCormick researchers says none of it would be possible without their Feinberg collaborator Dixon Kaufman. Kaufman arrived at Northwestern 18 years ago from the University of Minnesota, where islet transplantation was pioneered. "I was recruited to start a pancreas and islet transplant program here," he says. "I was the first and only one at the time working in that area."

In 2001 one of Kaufman's students attended presentations of Stupp's IBNAM incubator awards program.

"He said, 'I met someone new, Sam Stupp, and he's got some interesting materials in nanotechnology,'" Kaufman recalls. IBNAM played an important role in helping integrate new collaborations and supported Kaufman with an incubator award in 2002. Later, Kaufman and Lowe, another collaborator, found out about Shea's work with microporous scaffolds and started working on a new project.

"We all have very similar personalities," Kaufman says. "Surgeons make things happen. We're pretty decisive. And when these guys are in their element, they make things happen, too. Our personalities mesh. The success of our collaboration really has to do with our collegiality and the innovation that everybody can bring to a focused area."

Grants were received, meetings commenced, and the engineers used Kaufman's mouse lab for testing. "It was fresh and exciting," Kaufman says. "It really expanded the intellectual input in this field. I think we were one of the first medical school and engineering groups to start working together on a very clinically relevant area of islet transplantation."

These days there are still only about 10 islet transplantation programs in the United States. The one at Northwestern performs about one procedure a month and, like every program, faces donor shortages. Although organs from about 7,000 deceased donors become available each year, according to the NIH fewer than half of the donated pancreases are suitable for harvesting islets. Still, Kaufman believes the procedure can one day be a cure for diabetes. "We want to transform lives," he says. "We want to get people who were diabetic insulin-free."

The procedure likely won't become a viable cure until stem-cell derived islets become a reality, Kaufman says. When that happens, islet transplants can be done efficiently and on a large scale. But such technology is still far off. Until then, it's important to find new ways to help transplant islets so that when the technology does arrive, these techniques can help ensure success.

"This is really an important paradigm of team science," Kaufman says. "Northwestern is becoming well known for its success in research endeavors based on medical and engineering collaborations."

Other treatments possible

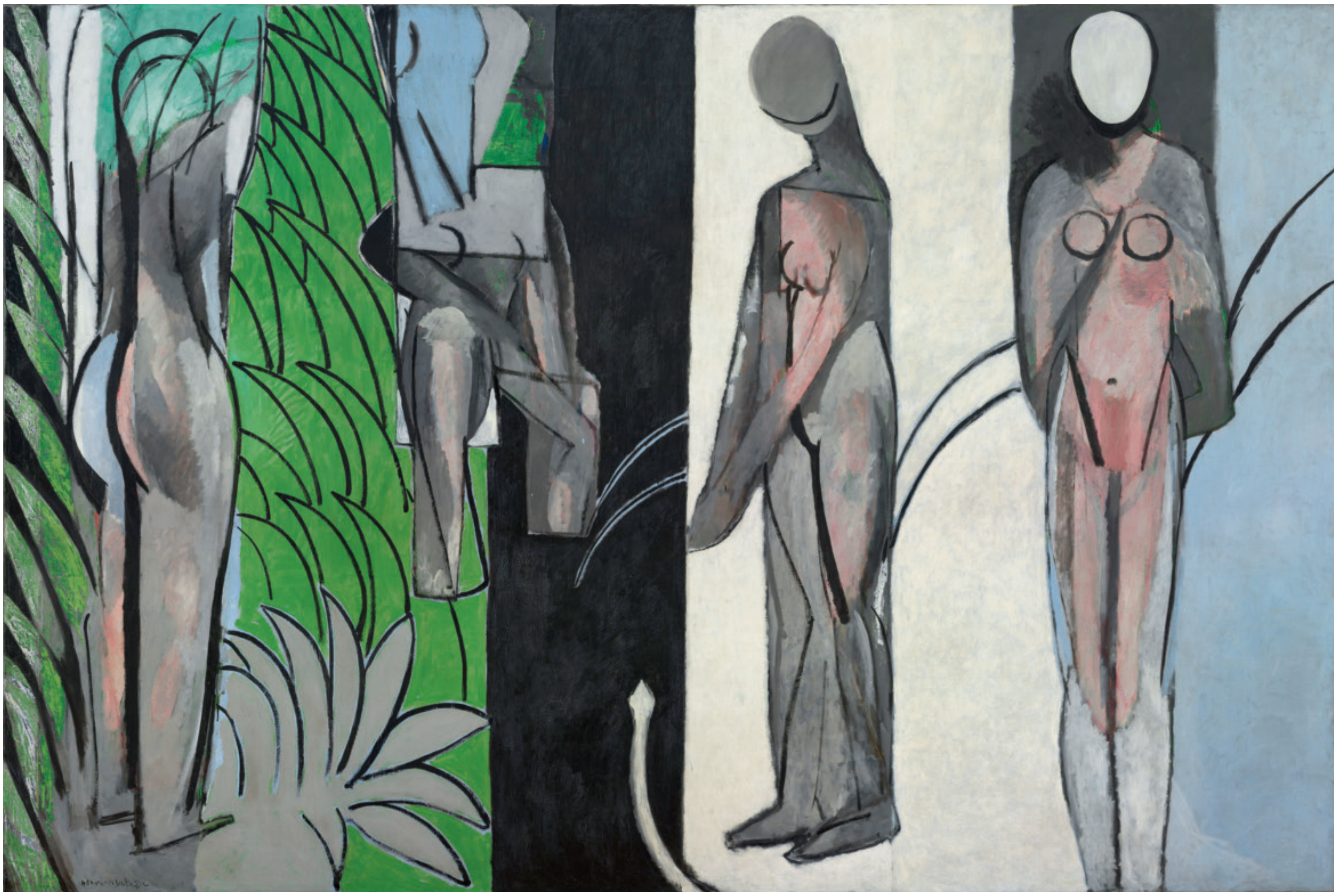
While stem cell–derived islets are now more science fiction than reality, Stupp is beginning to work on another possible cure for diabetes: nanostructures designed to turn faulty islets back on.

"Our vision is to produce a type 2 diabetes therapy that we could introduce systemically," Stupp says. "People would get an injection of these nanostructures, which would navigate through the blood stream to the pancreas and give insulin-producing cells within islets signals to survive and produce insulin."

Such a therapy would affect a large number of patients, but the lab is just beginning to create the nanostructures and test them in vitro with cells. "Diabetes is a growing problem," Stupp says, "But this research has implications beyond the disease. That is what makes this specific idea such a good target." M Emily Ayshford

art + science

PROFESSORS CREATE TECHNOLOGY TO COLORIZE ARCHIVAL PHOTOGRAPH OF MATISSE MASTERPIECE



Henri Matisse (French, 1869–1954), *Bathers by a River,* 1909–10, 1913, 1916–17. Oil on canvas. 102½ x 154³⁄₁₆ inches. The Art Institute of Chicago, Charles H. and Mary F. S. Worcester Collection, 1953.158. © 2010 Succession H. Matisse/Artists Rights Society (ARS), New York.

THE PROJECT WAS THREE YEARS IN THE MAKING — three years of attempting to meld art and science, of coding and assessing and then coding again, of using historical narratives and supercomputer clusters to solve the mystery of a modern masterpiece — and at the last minute before deadline, something wasn't quite right.

McCormick faculty members Aggelos Katsaggelos and Sotirios Tsaftaris had developed extensive algorithms to colorize a black-and-white photograph of Henri Matisse's *Bathers by a River*. The photo ①, taken in November 1913, showed a painting very different from the one, believed to be finished in 1917, that's part of the Art Institute of Chicago's collection. Using clues about which colors went where — established through microscopic samples taken from the painting that revealed, like geological ages, layers of decision from the mind of Matisse — the team created a series of equations that assigned a color to each pixel of the photograph ②.


1


2

Francesca Casadio and Aggelos Katsaggelos at the Art Institute of Chicago's *Matisse: Radical Invention, 1913–1917* exhibit in June. *Photo by Sally Ryan.*

After three years they thought they were finished. Tsaftaris, research assistant professor in electrical engineering and computer science at McCormick and of radiology at the Feinberg School of Medicine, proceeded with a planned trip and returned to work only to find an e-mail saying one part of the photograph wasn't quite right. And if it wasn't right, it wouldn't be included in the exhibition catalog for the upcoming Matisse exhibit at the Art Institute, curated by Stephanie D'Alessandro at the Art Institute and John Elderfield at the Museum of Modern Art in New York.

So Tsaftaris spent nine hours using the Northwestern supercomputer cluster rewriting the equations and running them through the computer in an attempt to make the photograph right. "It was emotional," he says. "But in the end, we did it."

Their colorized photo became part of the *Matisse: Radical Invention, 1913–1917* exhibit on display at the Art Institute last spring before it headed to the Museum of Modern Art. The photo provided evidence of an early version of the painting and insight into Matisse's artistic evolution.

Seeking a connection

"Emotional" is a word Tsaftaris uses a lot when talking about the project. Both he and Katsaggelos, professor of electrical engineering and computer science, are Matisse fans. The artist is part of Tsaftaris's family memories — his sister wrote her college art history thesis on Matisse, so her dorm room was plastered with posters of the master's work.

> "This is a way of exposing people in the sciences to art, and in art to the sciences."
> FRANCESCA CASADIO

Katsaggelos and Tsaftaris did not know they would work on the Matisse exhibit when they first met with Francesca Casadio, the A. W. Mellon Senior Conservation Scientist at the Art Institute. Casadio is often the bridge between the worlds of art and science, acting as the interpreter between conservators and engineers.

When the Art Institute hired Casadio in 2003, it established a scientific laboratory and began collaborating with McCormick on projects, including examining the composition of jade and bronze sculptures (which provides clues about artists' materials and methods and the provenance of pieces) and examining the chemical processes behind the discoloration of pigments in paintings such as Georges Seurat's *Sunday on La Grande Jatte* (see the spring 2006 issue of *McCormick by Design* magazine).

"It's a matter of finding a connection between the expertise available at McCormick and the questions that are intrinsic to many works of art," Casadio says. "With *Bathers,* the curators knew there had been changes, and we knew it would be extremely important to be able to colorize the historical photograph that had been unearthed. It seemed like the perfect project for Aggelos and Sotirios."

Bathers by the River is considered one of Matisse's greatest masterpieces. According to the Art Institute, it began as one of three panels commissioned for a Moscow collector. The first version was a stylized rendering of five nude females near a waterfall; when the collector decided not to purchase the work, Matisse eliminated a figure and transformed the nudes into abstract forms.

Taking clues from the past

The photograph at hand was taken by Eugène Druet. Katsaggelos and Tsaftaris, whose research involves image processing (Katsaggelos's previous work in his 25 years at Northwestern has used algorithms to fill in animation or repair color on scratched films of Disney animations), became excited about the challenge. Seed money from the Andrew W. Mellon Foundation gave the project a boost. All they thought they needed were good clues — some initial color values — to get them started.

"The algorithm we developed takes a color and propagates it to the rest of the image," Katsaggelos says. "It takes into account both the intensity and the luminosity of the color."

The project took time to get off the ground. The initial images they received weren't the right resolution, and they found that colors on their computer screens looked different from those at the Art Institute — a common issue in image processing.

Once the resolutions of the black-and-white photo and an image of the current painting were synced, the duo began working with the Art Institute to determine which colors went where. Kristin Lister, a paintings conservator at the Art Institute who treated and studied the Matisse painting, had removed tiny samples — one-sixteenth of an inch wide — in areas where Matisse had changed the painting. Inge Fiedler, microscopist in the conservation department, mounted and analyzed the pigments in these tiny cores — some of which had 13 layers of paint. The research team then cross-referenced the pigment samples with the photograph and accounts of people who had seen the painting in its earlier states.

Early tests showed there was another factor to take into account: the lighting in the photograph. One corner seemed to have a higher intensity than the rest — either from a flash (likely a magnesium flash used at the time) or from the skylights in the gallery where the photograph was taken. "We had to do a histogram analysis of the photograph and figure out the distribution of light," Tsaftaris says. "We had to correct for the aberrations in the intensity of the light." That required extensive calculations and computing, and even some pixel-by-pixel work.

Sotirios Tsaftaris

Even then, the colorized photograph wasn't quite right. "They said, 'It seems too dark. We expected more intensity,'" Tsaftaris says. "So we had to go back to the drawing board and figure out what happened."

Finding a common language

The duo worked closely with Lister, who, inch by inch, had removed varnish from the painting's surface and knows it intimately. Though she had worked with scientists before on new imaging methods as well as on pigment and medium analysis, working with Tsaftaris and Katsaggelos involved a learning curve in both science and communication, she says.

"These engineers are certainly not dry scientists," she says. "They are passionate about their science." She admits she doesn't fully understand how their algorithm worked and said their miscommunication often involved objective versus subjective judgments. "They wanted to do it based on fact, but for us it was more a matter of what looked right based on both greater familiarity with the cross-sections that could not be objectively translated to the algorithm and conservation and curatorial knowledge of Matisse's work of the time. So we would get together and fine-tune things."

Along the way Katsaggelos assigned the project to undergraduate students in his courses, asking them to look at different colorization techniques and to test existing algorithms to see how they would perform in this situation. "It has been of great interest for students," he says. "They can apply their ideas and algorithms to pieces of art. It's a good way to attract students to computer science and engineering. It shows them they can work on exciting problems."

Finally, after the last push from Tsaftaris to get the final colorization as close to reality as possible, the colorized photograph was ready for the exhibition. "When it eventually all congealed into what we thought was the closest approximation, I could see the sparks in the curator's brain," Casadio says.

A missing piece of the puzzle

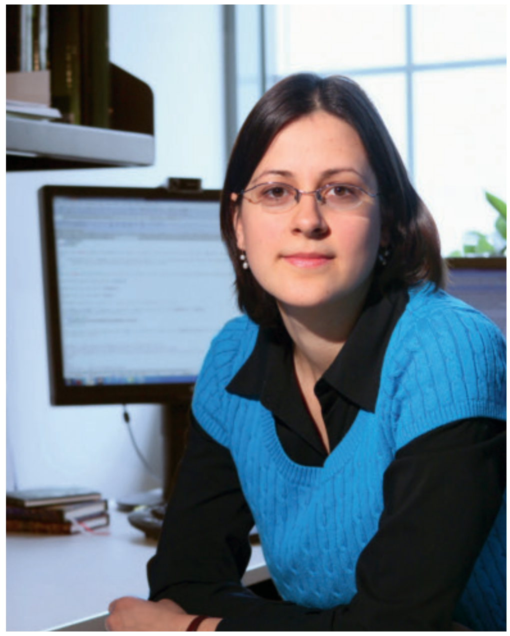
The colorized photograph revealed that the painting — which presents somber gray tones alongside bright shades of lush green and vivid peach, the hues of an artist known for his mastery of color — was once composed of mostly gray washes. The color and technique of this earlier state gave the painting an atmospheric effect, as though the bathers are being viewed through a mist.

"No one had any idea that he painted it in mostly grays, with shafts of pink and turquoise," Lister says. "An artwork is a communication between artist and viewer that doesn't need to be translated into words. It is direct and inspiring. The more we understand the visual message, the more we come to appreciate the artist's particular depth of expression. That's why art historians and conservators, with the aid of scientists, are always looking for new ways to get under the skin of and clarify a work of art."

The colorized photograph, which became not only part of the exhibition catalog but also was on display in the exhibit, is "very, very powerful," Casadio says. It allows art historians to connect the painting with other Matisse works that share a similar palette, and it also shows both brushwork and texture that varied from the final work. It was the first time that colorizing techniques were developed and used to research earlier versions of artworks, and there is already talk of colorizing a photo of a Picasso painting for another research project.

"This is something that is going to revolutionize the field," Casadio says. "Oftentimes we do collaborations, and everyone publishes in their own professional journals. It's nice to see everything come together and be presented to the public. This is a way of exposing people in the sciences to art, and vice versa."

Tsaftaris believes that these algorithms could also be used to colorize medical MRI images to make diagnosis of disease easier and more accurate. For Katsaggelos, the project was a chance to bring his research — normally accessible only to colleagues — into the public eye. "It was inspiring," he says. "It's a project you can talk to your kids about and they can get excited about. This marriage between computer science and other disciplines can definitely push the envelope of what can be done in art and science." M Emily Ayshford



HUMANITARIAN LOGISTICS

SAVING LIVES WITH BETTER DISTRIBUTION MODELS

For Karen Smilowitz and Irina Dolinskaya, the term "industrial engineering" is a bit of a misnomer. It evokes the image of the engineer in a factory with a stopwatch in hand, making sure production is as efficient as possible.

Surely some industrial engineers still do that. But these days, industrial engineering has grown beyond the factory and into the world of business. Smilowitz has taken it one step further — into nonprofits.

Smilowitz, associate professor of industrial engineering and management sciences and William A. Patterson Junior Professor in Transportation, has studied ways to optimize how freight is moved: how to reduce the distance of trucking routes, for example, or how to get companies to pool their resources and lower costs. More recently, she has taken that work and applied it to nonprofits, including finding the most efficient way to route library books and improving operations for a mobile asthma-care organization.

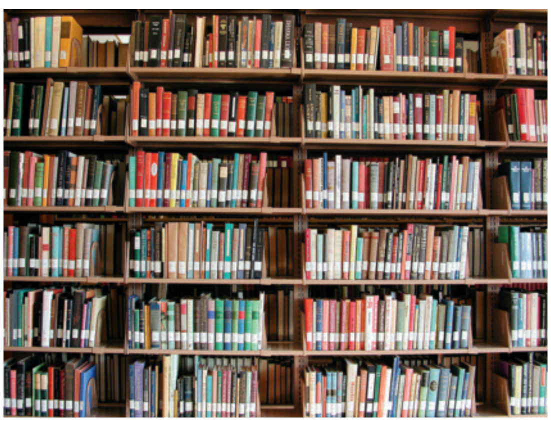
Now, she and Dolinskaya, assistant professor of industrial engineering and management sciences, are working together to use their operations research in a new area: disaster relief. It's a field known as humanitarian logistics, and — as seen with disasters in New Orleans and Haiti, where workers faced roadblocks in distributing provisions to survivors — it could have far-reaching implications.

Optimizing models — but not profit

Nonprofit and humanitarian organizations often have operations problems they don't have the budget or technology to solve, and their needs are different from those of for-profit companies. "When you have a nonprofit, the goals change," Smilowitz says. "You can't just take a commercial model and apply it, since maximizing profit and minimizing cost aren't necessarily the goals."

For example, in one of Smilowitz's research projects, local libraries faced a unique dilemma: vans visited each library in the system every weekday to pick up and drop off book requests. As the economy crashed, demand for library books went up — but it was no longer feasible to provide the van service every weekday. What Smilowitz found was that instead of going only to certain distant libraries every other day, the route could be optimized so drivers would go to each library three days a week, giving every library greater service.

"We found this counterintuitive result where we can reduce transportation cost and increase service," she says. "This opportunity is unique to



Karen Smilowitz, left, and Irina Dolinskaya are creating new models for distributing goods after disasters. *Photos by Andrew Campbell.*

nonprofits. In a for-profit setting, if you don't pay for a level of service, you don't get it. But we uncovered this new variation of the vehicle routing problem, which is really exciting."

Smilowitz and her Northwestern colleague Seyed Iravani, professor of industrial engineering and management sciences, have worked with a food bank in Chicago to find the best way to match donors and recipients and design delivery routes to serve people. And along with Sarang Deo, assistant professor of managerial economics and decision sciences at the Kellogg School of Management, they are working with Mobile C.A.R.E., a nonprofit that provides free asthma treatment to children in Chicago's underserved communities via mobile medical units. Beginning last spring, a team of undergraduates began surveying the organization's operations and started to create a simple model of how to make its operations more efficient.

> "When you have a nonprofit, the goals change. You can't just take a commercial model and apply it."
> KAREN SMILOWITZ

"You need to have a model that shows how asthma progresses over time," says Smilowitz. "And you need a capacity-allocation model that says how to best use a scarce resource when your objective function is to bring in the entire population. It's a difficult problem."

Responding to disasters

When Dolinskaya came to Northwestern in 2009, she and Smilowitz — whose offices are next door to each other — began to talk about collaborating. Smilowitz had done some work in disaster relief, and Dolinskaya had worked with the U.S. Navy in charting optimal courses for sea vessels using real-time information to continually update the route based on radar data about the sea's roughness.

When the earthquake hit Haiti in January, Dolinskaya and Smilowitz started to think about how their research could apply to the relief efforts. They knew they had strengths in transportation and vehicle routing, so they began talking to relief organizations like FEMA and the Red Cross to get information on how disaster relief efforts usually work. "It seemed like a very natural coming together," Dolinskaya says. "Karen was working on the distribution of goods. In order to distribute them, you're trying to get to a destination, and you are learning about the environment as you are traveling — like what roads are impassable. I am interested in dynamically reevaluating a path as new information becomes available. It was a good fit."

Their research program, which is just getting off the ground, consists of identifying best practices in relief-chain management and developing new design and operating policies that can complement those practices. They are particularly interested in last-mile relief distribution, creating optimization models that can help drivers choose routes and allocate inventory once supplies have been delivered to their destination.

"When a disaster happens, you have a set of aid recipients who are geographically dispersed," Smilowitz says. "There is uncertainty: Maybe a road is no longer reliable, and you don't know how long it's going to take to get somewhere. How do you schedule visits? How do you build models that incorporate these uncertainties and take into account supplies, infrastructure, and the needs of the recipients? We don't just want to solve one problem for one organization in one disaster. We want to create models that incorporate baseline disaster scenarios."

Smilowitz and Dolinskaya hope to not only come up with optimization models based on baseline disaster scenarios but also to create rules of thumb that workers can use on the ground. "Relief workers can't use a model that they have to dynamically update and optimize every day," Smilowitz says. "I think it's one of the fun challenges to pare down these models into simple guidelines."

Both Smilowitz and Dolinskaya are affiliated with Northwestern's Transportation Center and hope to work with professors there, including center director Hani Mahmassani, on extending the initiative to evacuation and disaster relief. Smilowitz says McCormick's humanitarian logistics work is attracting graduate students with a background in quantitative research who are interested in using it for the greater good. "It is an effective way of approaching a problem, and students are learning it is one of the ways you can make an impact in the world," she says. M Emily Ayshford



Human-centered design

Undergraduates are finding whole-brain solutions for those who need them most

Colin McNary looks like any other rambunctious 10-year-old kid: he runs around smiling, clad in a T-shirt and jeans. But when it comes to communicating, Colin faces challenges beyond those of a typical 10-year-old. When most kids want something, like ice cream, they can just ask for it, or plead for it, or even try to negotiate for it before their parents' denial is reflected back in the form of a first-rate tantrum.

But Colin, who is autistic, can't communicate using speech, save a few words, and when he can't communicate — can't even begin to say that he wants ice cream — he becomes aggressive. A simple want quickly becomes an outburst.

His parents, Mia and Tim McNary, knew early on that Colin had trouble communicating and worked to secure him an augmentative alternative communication device — AAC, for short — when he was five. The touch-screen computer with dozens of images allowed him to learn how to make complex sentences. For the first time in his life, Colin had a voice. Mia lugged around the five-pound device wherever they went. "If we were going to the grocery store, I brought it with," she says. "He needed his voice."

When it came time to send Colin to school, the McNarys, who live in Illinois, decided the best place for Colin was Heartspring, a nonprofit center for children with special needs in Wichita, Kansas. Each day at Heartspring Colin carried the AAC in a heavy, satchel-like carrying case. It was a lot for him to handle: the design of the case caused the device to bang against Colin's chest and bruise him, and he often dropped the case or bumped it into walls and desks. "It kept getting broken, and it takes three weeks to get it repaired," Mia says. "He would lose a lot of ground that he gained."

In 2008 Mia McNary — whose father is Bill White, professor of industrial engineering and management sciences at McCormick — heard about the Engineering Design and Communication course at McCormick and wondered if Colin's case would make a good project. "I felt that engineering students could feel good about a project like this," she says. "It wasn't high-tech, but we hoped that students would understand that it would help children with disabilities."

Stories like these are behind many of the undergraduate design projects at McCormick. From the first-year Engineering Design Communication sequence to upper-level courses and certificates in the Segal Design Institute, McCormick encourages students to take on special client-based projects in which they diagnose design problems and find solutions. Not every project is an immediate success; some take years and several different groups attempting different solutions. But many have the right mix of student motivation, analysis, and creativity that gives clients — whether an autistic child, a scuba diver who was born without arms, or employees at a nonprofit botanical garden — practical ways to make things easier.

"Undergraduate design courses give students a wide range of design experience," says Bruce Ankenman, associate professor of industrial engineering and management sciences and director of undergraduate programs at McCormick's Segal Design Institute. "They also provide design solutions to individuals and nonprofits that lack vast resources or have a problem for which a solution isn't commercially viable. It's a win-win."

Giving Colin a voice

Colin's project was taken on in early 2009 by first-year students Keshav Rajam, Kevin Lu, and Lauren Nelson. They knew right from the beginning that they wanted to make Colin a new kind of case for his AAC. "We needed something to make the weight more even on him," Nelson says.

"He had to carry his old case with one hand and press the buttons on the AAC with the other," Rajam says. "We wanted a solution that held the device in place while he pushed the buttons."

The team worked with Lindsay Salomon, director of school therapies and applied technology at Heartspring. Through e-mails and

Colin McNary poses with his mother, Mia McNary, and grandfather Bill White. A team of freshman students helped design a new carrying case for Colin's augmentative alternative communication device. *Photos by Andrew Campbell.*

> "They provide design solutions to individuals and nonprofits that lack vast resources or have a problem for which a solution isn't commercially viable. It's a win-win."
>
> BRUCE ANKENMAN

Skype conversations, she helped the team work through the design of the new case. "It was great," she says. "They were always well organized and asked good, in-depth questions. They were very passionate about helping a student with autism use his device more effectively."

Rajam, Lu, and Nelson bought a $20 backpack, cut off the straps, and then went to work in the basement shop of McCormick's Ford Motor Company Engineering Design Center. They knew they wanted straps on each shoulder but had trouble figuring out how to attach the AAC to the straps so that Colin could easily remove it. (The answer: Aluminum rings.) They created a waist belt that would help distribute the weight of the device more evenly. The team then developed a set of "suspender straps" that allowed Colin to pull the device out from his chest and hold it horizontally for use. "That was the most innovative part of the design," Nelson says. "He could type on the device without holding it in his hands."

The rest of the project involved finding materials — the right plastic for the case cover, the right adhesive to attach the cover to the case (hot glue), and the right mesh to keep the AAC cool — needed to make the case ready for testing. Nelson, who grew up in the south suburbs of Chicago and worked with special-needs students in high school, went back to her alma mater to do user observations. "Watching the students use it was really helpful," she says. "It showed us that we really needed to make the straps adjustable."

At the end of spring quarter 2009, the team presented the idea to Lindsay Salomon, Mia McNary, and Bill White.

"When I saw what they did, I almost started crying," Mia says. "I could immediately see how it would help him and affect his behaviors."

When Colin was presented with the new carrying case, he walked up to his teacher and, using a few of the words he can say, said, "Give me a kiss." "Everyone in the room went, 'Whoa, what did he say?'" Mia recalls. "He knew exactly how it would impact his life."

A year later the effect is clear: by having easier access to his AAC, Colin can more easily communicate what he wants and has had fewer behavioral problems. The device also has a secondary effect of giving Colin the sensation of being hugged, which helps remind autistic people where they are in space. The case is now part of his daily routine: when he gets dressed in the morning, the first thing he does is snap on the carrying case.

"When he stomps his feet, we can catch him before there is a problem because his device is easy to get to," Mia says. "We can have a conversation through the device, and he realizes that we are identifying his needs. The students did such a great job. It was the greatest gift."

For Rajam, Lu, and Nelson, it was a chance not only to work with a client but to create something that would change a child's life. "For me it really hit home," Nelson says. "I really enjoy working with special-needs students, and it was great to be able to continue that in college. It was great to hear Colin felt comfortable with it. That made everything we worked for worthwhile."

Indeed, the device may be just a little too comfortable: earlier this year, the McNarys had to send the AAC back for repairs after Colin plunged into a puddle with it still attached to his chest.

Student John Steger tests modified scuba gear in a Northwestern pool. Above left: The team of engineering students who helped design the gear for a scuba diver who has no arms. *Photos by Andrew Campbell.*

Diving into the deep

It's hard not to be inspired by Jessica Cox. Born without arms, she has devoted herself to living an extraordinary life. She uses her feet to perform not only everyday tasks, like driving a car and putting in contact lenses, but also demanding feats like swimming, biking, and flying airplanes.

But when it came to conquering her latest challenge — scuba diving — Cox needed a little help. Traditional scuba gear is built for people with arms, so Cox found herself in an ill-fitting harness that didn't allow her to control her body while underwater. She required scuba gear made especially for her needs. A group of juniors and seniors in the Segal Design Institute's Interdisciplinary Design Project sequence wanted to make it happen.

"Everyone on the team applied to be on this project," says Andrew Hutton (manufacturing and design engineering '10). "It was an exciting project, and we knew we were going to have a lot of human interaction."

The team quickly found it needed to modify conventional scuba gear to help Cox keep her center of gravity in the water. "When she cleared water from her mask, she would tumble out of control, lose her orientation, and start sinking rapidly," says Tyler Johnson (mechanical engineering '11), who is himself an experienced scuba diver.

Right: Students Ariel Wagner and Max Willer with Boyce Tankersley, director of living plant documentation, and Nathanial Gish, former labeling technician at the Chicago Botanic Garden. Opposite, top to bottom: Radio frequency identification gear; a plant tag that can be read from several feet away with an antenna; current plant tags at the garden, which can only be read manually by volunteers. *Photos by Sally Ryan.*

"We needed to find a way to stabilize her and make it safer and easier for her to control her buoyancy in the water."

The team spoke with Cox's instructors at Diveheart, a nonprofit organization that works with divers with disabilities, and decided the best way to crack the problem was to jump right in the pool at Northwestern's Henry Crown Sports Pavilion and Norris Aquatics Center. (They used teammate John Steger [industrial engineering and manufacturing and design engineering '10], who had no scuba experience, as a test case.)

"We used birthday balloons to try to control buoyancy and tried to simulate Jessica's experience as best we could," Johnson says. The team quickly got a physics lesson in buoyancy. The center of buoyancy tends to be directly above the center of mass in a body in water. Moving the center of buoyancy would increase stability, but how could it be done?

"We learned that extra pockets of buoyancy are a good thing," says Henry Petrash (manufacturing and design engineering '10). The students added a pouch of foam on the top of the harness, which allows Cox to stay upright in the water. They figured that Cox could better control her buoyancy and stability if she had easier access to the low-pressure inflator hose, which divers use to control their buoyancy to ascend or descend in the water and which is normally located on a diver's chest. The team moved this hose down to the knee "so Jessica would be able to alter her buoyancy quickly with the same ease, speed, and comfort as a diver who has arms," Petrash says.

Despite the team's excitement, the design process had starts and stops. When the students tried to design a harness clasp that Cox could control with her foot, they got a lesson in how a design that works on paper doesn't always translate into the real world and ended up going with a simpler leg harness that prevents the gear from sliding off Cox's shoulders. The group also observed that when you get a group of four college guys together, the conversation tends to wander, and an hour later, nothing is done. Toward the end of the first quarter, they had a team meeting over Google chat. "That ended up being a landmark moment," Petrash says. In true college fashion, they did most of their design review brief that night.

Throughout the two quarters they worked on the project, the team e-mailed Cox, who lives in Arizona, to get her opinion on aspects of the design. "One of the most important parts about design and engineering work is the client interaction," Hutton says. "Finding what's most appropriate for a project while meeting the client's demands is something that we've been able to experience. You're not just out there inventing crazy things. You're doing it with a client in mind."

"Our project was inspirational," Hutton says. "We balanced our technical understanding of the project with a human touch. Jessica is an inspirational person. It's easy to work on a six-month project when you have that driving you."

The team presented its idea at the end of spring quarter 2010, and Cox listened in via Skype. Cox is excited by the redesigned gear and says she can't wait to try it out when she goes scuba diving this fall. "Knowing that these students — whom I never even met in person — chose to dedicate six months to engineer the scuba gear is very touching," she says. "They have given me wings underwater!"

Speeding the census of plants

On 385 acres of woods, lakes, prairies, and formal gardens, the Chicago Botanic Garden — which sits 10 miles north of Northwestern's Evanston campus — is a suburban oasis and a major destination for Chicagoans who need a break from the bustle of the city.

Here visitors find a pristine array of plants and trees, from serene Japanese bonsai trees to hot-pink rose bushes, which garden staff have gathered from around the world. Cataloging the 2.5 million plants in the collection is no small feat for the garden's four-member plant record staff and 85 volunteers. Together they do a formal inventory of the garden manually, verifying that the plants match the computerized maps and inventories, and then enter that information into a database. The process takes an astonishing seven years, and it is riddled with errors.

"We thought there had to be a technological aid that can help us get past this hurdle and speed this process up," says Boyce Tankersley, director of living plant documentation for the garden.

Several years ago Tankersley looked into purchasing a radio frequency identification (RFID) system that staff could use to automatically read information off special tags via an antenna. But the system they tried failed miserably: it couldn't read the tags well enough, especially in less-than-pristine conditions (like harsh Chicago winters). So Tankersley enlisted the help of the Segal Design Institute, which assigned the project to students in the Interdisciplinary Design Project sequence.

"Our team was made up of a mechanical engineering major, a biomedical engineering major, a manufacturing and design major, and

an environmental engineering major," says Max Willer (mechanical engineering '11). "We knew nothing about RFID systems."

The students began by cold-calling RFID manufacturers to ask whether they could borrow a system to try it out, figuring it wouldn't be hard to find a charitable company willing to help out a group of students working on a project.

They were wrong. "It wasn't easy to get a hold of people who wanted to help," Willer says. "It took a long time."

"We weren't designing a product; we were designing a system," says Ariel Wagner (manufacturing and design engineering '10). "We had to talk to different companies and put together different products that made sense. It was the first time I had to go out into industry and convince them to work with us."

Finally, one company — Omron — agreed to let the team use an RFID reader, and William Frick and Company, a manufacturer of specialty labeling and marking products, agreed to custom-make RFID tags. The team then had to decide what type of tags to use: active tags with a broader range that require batteries or passive tags with a shorter range that require no power. The students decided active tags powered with solar cells were the answer. Then they ran into their first real-world problem: cost.

Eventually they found the best solution was a high-powered tag reader — the kind used to ping goods on a truck as it leaves a warehouse — with passive tags. With these tools, garden staff could walk or drive around with the reader (about the size of a laptop computer), point it at plants throughout the garden, and read the tags. The team tested the system to make sure it could pick up the tags under actual conditions — the problem that Tankersley had run into previously. Most plants in the garden are 10 to 20 feet from the path, and many are blocked by branches or other plants and for much of the year are covered by more than a foot of snow.

"A lot of problems with RFID range has to do with moisture in the air," Willer says. "So we tested the system both in the snow and in the semitropical greenhouses."

Tankersley made sure the team tested the system in the worst possible conditions. "I had them test one tag that was buried within a shrub, in a hedge, under two feet of snow," he says. "The system read through it all. I made them repeat the test, and then I smiled from ear to ear."

The students performed one test where they hid eight tags in eight plants within a 10-foot radius. Normally, a volunteer would hunt for those eight tags and write down the information, taking about 30 seconds per tag. With the new system, a worker walked down the path, held out the reader, and picked up all eight tags within 30 seconds.

The team's goal, as defined by the Chicago Botanic Garden, was to come up with a system that could reduce the time it took to complete the inventory to five years. Using the system designed by the McCormick undergraduates, a full inventory could be done in one spring-summer season. "The system they came up with is so cool," Tankersley says. "They thought outside the box. That was what really gave us a thrill. Within a couple of quarters they developed a solution for us."

For the students, the project presented a new sort of design challenge. "I've never designed an inventory system before," says Wagner. "In school we work with real clients, but it's mostly designing products. Designing a system on a scale of hundreds of thousands of items was new, and it was a good learning experience."

"There was less brainstorming and more optimizing," says Willer. "You have a straight and narrow problem — a reader and a tag. We had to figure out how they could work together, and how to optimize it for both price and range."

The Chicago Botanic Garden's inventory project has implications beyond just keeping track of what is on the grounds. The garden collaborates with conservationists in captive breeding programs to interbreed endangered plants and reestablish them in the wild. The garden has also partnered with more than 2,000 gardens around the world to build a "Noah's Ark" of plants. The program, aimed at preventing the loss of biodiversity, is a registry of which plants each garden has — and which plants they are missing.

The solution the McCormick students devised still needs to be presented to and passed by the garden's board of directors, but Tankersley is already considering other projects that Northwestern engineers could work on. "We're plant geeks, and when it comes to engineering, we're totally clueless," he says. "It was fun to stand back and watch their minds click." **M** Emily Ayshford

Pioneering career

Ginni Rometty ('79) has succeeded by putting people first

IN THE LATE 1970s Ginni Rometty was like most first-year engineering students at Northwestern: she knew she was good at math and science, but she didn't know what she wanted to do with those skills. She decided to major in computer science, then a budding field, and so her undergraduate years were spent lugging around boxes of programming punch cards and scheduling time on the giant computer systems, which meant many late nights and an uncommon commitment to her studies. Rometty still remembers the computer she used: the PDP-11. "Anything we did on that computer you could do on your phone today," she says.

Since then Rometty herself has evolved from engineering student to senior vice president and group executive for sales, marketing, and strategy at IBM. She's been named to *Fortune* magazine's "50 Most Powerful Women in Business" five years running, and she led the largest acquisition in professional services history. In her current position she is responsible for revenue, profit, and client satisfaction in the 170 global markets in which IBM does business.

At McCormick's undergraduate convocation last June, Rometty reflected on how Northwestern helped shape her future. "I never would have guessed," she said, "when I was sitting where you're sitting now, that I would be fortunate enough to meet with hundreds of corporate and government leaders every year, travel millions of miles, and now help lead an organization with revenues that are higher than the GDP of three-quarters of the countries in the world. Much of what I have accomplished I owe to this great institution."

Rometty was one of only a few female students studying computer science in the 1970s. She tells of running into a male classmate recently from an electrical engineering class and failing to come up with his name. "He said, 'That's okay. There was one of you and 50 of us,'" she laughs. "But it was a very nurturing educational environment. I was around lots of kids who were smart and bright and who had good social skills. But the thing Northwestern does above all else is teach you how to solve problems and how to think. Then you figure out what you are passionate about and apply that thinking there."

After graduating in 1979, Rometty took a position that left her unsatisfied. That experience quickly taught her the difference between a job and a career: "I learned that jobs are what people do from 8 to 5, and careers are things they are passionate about. That's what led me to IBM. I like technology, but I didn't want to just do technology. I wanted to apply it. I learned how to think at Northwestern, and at IBM I could apply that thinking."

Her résumé at IBM is impressive. Before rising to her current position she served as general manager of IBM's global insurance and financial services sector, general manager of IBM global services, and senior vice president of IBM global business services. In that last position she led the successful integration of PricewaterhouseCoopers Consulting into IBM — a record-breaking acquisition involving a global team of more than 100,000 business consultants and service experts.

"I've spent the majority of my life away from hard engineering," she says. "I've been in technical sales, sales, and consulting. It's the idea of being T-shaped. You need really broad business acumen, but you also need an area where your knowledge is deep. From that emanates your confidence to try other things. What Northwestern did was give me that foundation. That is what has allowed me to traverse different careers."

Rometty takes that message on the road when speaking to potential female engineers. She is a leader in national diversity initiatives, such as the Women in Technology Council and the Women's Leadership Council, and is one of the senior sponsors of the Women's Executive Council at IBM. "I try to get women to go into math and science," she says. "I try to convince them it's a solid foundation that gives them the confidence to tackle just about anything."

Rometty has been so successful in part because she believes in putting people first — she's known for her customer service. "I have a huge passion for clients," she says. "None of our businesses would exist without them. In my position I'm responsible for those relationships across the company, and today that's all about how to change their businesses and make their businesses successful. It's not about technology. It's about how to drive outcomes for them in a world that's become very volatile and complex and full of opportunity. I can't think of a better job to have at a better time. An environment like this is always full of opportunity."

Rometty credits her education with helping her broaden her skills beyond math and science. "I believe you can apply science to any industry, using both the left and right sides of your brain," she says. "The interdisciplinary curriculum at Northwestern allowed me to develop that. It infuses the way you think and gives you a broad portfolio of skills."

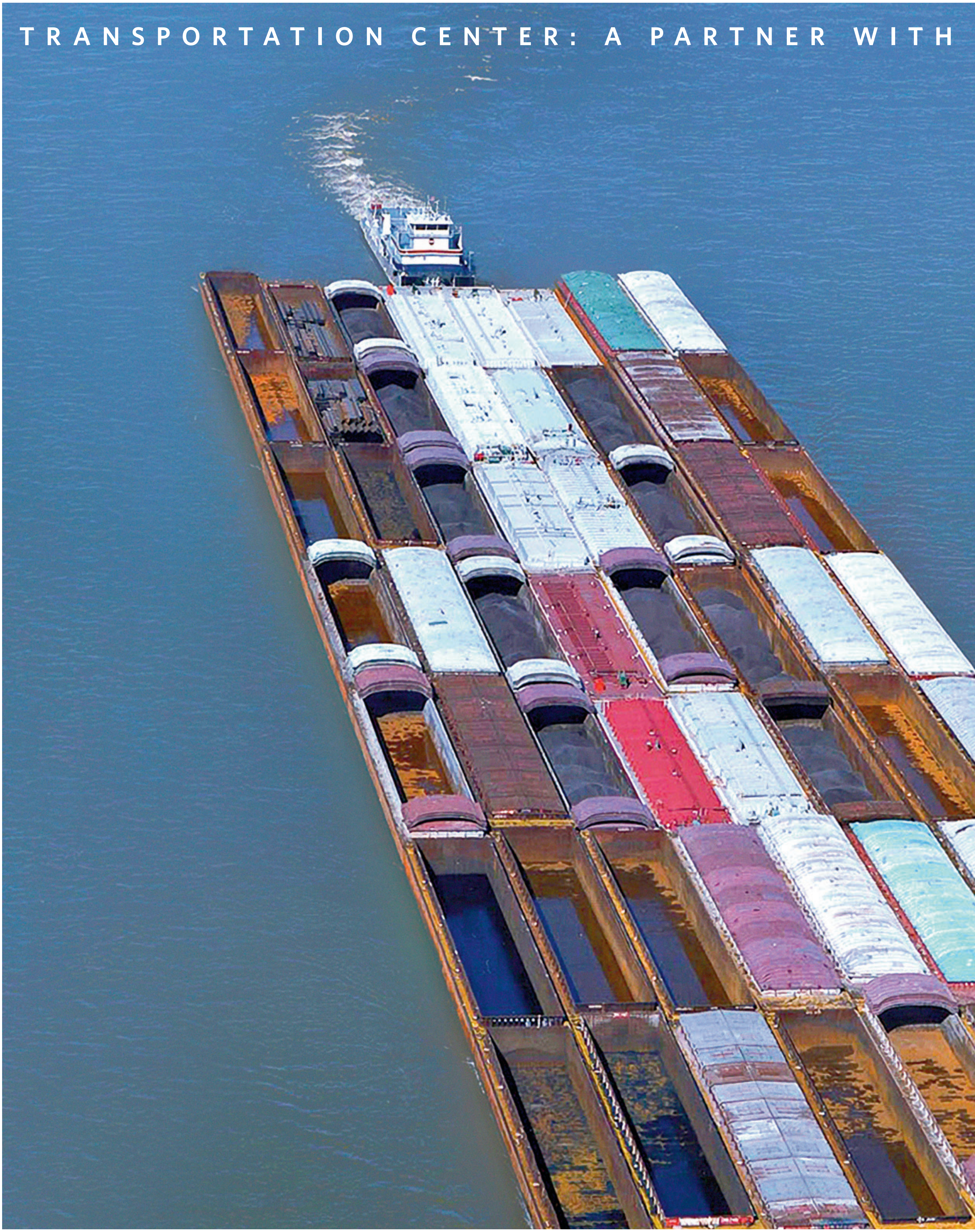
Now, 30 years after her graduation, Rometty is becoming more involved at Northwestern. This fall, she received the Alumni Merit Award and joined Northwestern's Board of Trustees.

"I think as you go on in your career you get a little bit of wisdom, and you reflect back on what contributed to who you've become," she says. "This is a small way to give back." M Emily Ayshford

"I try to get women to go into math and science. It's a solid foundation that gives them the confidence to tackle just about anything."

GINNI ROMETTY

TRANSPORTATION CENTER: A PARTNER WITH



INDUSTRY

CONSIDER LIFE ON A BARGE

If you're a crew member on an Ingram Barge Company towboat, you spend 28 days straight navigating, maintaining engines and auxiliary equipment, or working as a deckhand — carrying and lifting equipment and tools in all kinds of weather, day and night.

This hard work isn't a 9-to-5 job either: Crew members usually work two six-hour shifts each day and have two-six hour rest periods off. But how much sleep and relaxation can workers get during these rest periods, and how does this impact their fatigue levels when they're on the clock?

Ingram CEO Craig Philip had considered that question but didn't know how to go about answering it. "Most of the transportation modes need to have people working 24/7," he says. "You have people who are going to be on the job when their bodies don't want to be. Operators in every transportation mode struggle to come up with their best possible work schedules."

> "Most of the transportation modes need to have people working 24/7."

Then, at Northwestern's Transportation Center, Philip met Fred Turek, the Charles E. and Emma H. Morrison Professor of Biology in the Judd A. and Marjorie Weinberg College of Arts and Sciences and director of the University's Center for Sleep and Circadian Biology. Philip's concern with the sleep quality of towboat crews turned into a research study conducted by Turek with funding first from Ingram and then from the American Waterways Operators.

"Operator fatigue is very important to the transportation industry," says Hani Mahmassani, director of the Transportation Center and William A. Patterson Distinguished Chair in Transportation. "It affects both the safety and the economics of their business, so much so that we had an entire industry sponsor this research."

It's through interactions like that of Philip and Turek that the Transportation Center and industry are inextricably linked; without the center as an intermediary, Philip might not have found Turek, and vice versa. They serve as an example of how industry partners with the Transportation Center on cutting-edge research.

"The challenging issues of transportation tend to come from the real world. The best transportation research is relevant, identifying and ultimately solving real problems," Mahmassani says. "Most transportation research entities have a strong engagement with government. We have that, but it's our industry engagement that really makes us special."

INDUSTRY INGRAINED IN CENTER'S HISTORY

When the Transportation Center — a leading interdisciplinary education and research institution dedicated to the long-term improvement of domestic and international systems for the movements of materials, people, energy, and information — was created in 1954 as one of the first of its kind in the country, it was organized largely by industry leaders. The Patterson Endowment that significantly supports it was named for William "Pat" Patterson, the founding chairman of United Airlines and one of the Transportation Center's original organizers. Construction of the center's building in 1999 was funded through corporate and private donations, such as that by the Chambers Family Trust, the legacy of Jerry Chambers, who founded the firm that became Clipper Express. Seventy high-level industry people from across the nation are members of the center's Business Advisory Committee (BAC), which provides information and strategic guidance about research, student internships, and annual contributions.

Through the center, companies partner with one

Left: Craig Philip, CEO of Ingram Barge Company. Right: Hani Mahmassani, director of the Transportation Center. *Photo by Andrew Campbell.* Opposite, top: An Ingram Barge. Opposite, bottom: Echo Global Logistics CEO Doug Waggoner.

of the more than 50 faculty members from across the University — from areas such as engineering, economics, management, neurobiology, and social sciences — on transportation research. Connections may be made, for instance, when a BAC member hears a lecture by a Transportation Center faculty member and contacts him or her, or at one of the "industry days" where faculty members visit with a BAC company to learn about its transportation problems. Companies may ask the center to perform research of interest to them, or they may fund research a professor is already performing. The company often provides the data needed for professors to perform the research.

When Philip and Turek partnered on the sleep study, Turek and his colleagues spent five months in 2009 studying the sleep of workers on five towboats. They found that some crew members spent about 4.5 hours in bed and got as little as 3.7 hours of sleep during the six-hour break.

Recent studies showed that performance levels depend on the total number of sleep hours per day, so crew members ostensibly could perform the same whether they slept for six consecutive hours or had six hours of sleep split into a four-hour "anchor" sleep period one time and a two-hour nap later. The researchers encouraged crew members to develop "novel napping strategies" that included having the longer anchor sleep at night, when the body's circadian biology wants it to sleep, and napping during the day to reach at least seven hours of sleep.

Some crew members slept longer thanks to the researchers' intervention, but the data set was too small for the researchers to reach any significant conclusions. They decided that further studies should be done to get a larger sample of sleep schedules and to determine why some crew members slept longer than others. Researchers hope this information will provide data to develop interventions to improve sleep and reduce fatigue for towboat operators across the industry.

Philip has a longstanding relationship with the Transportation Center and joined the BAC about 10 years ago. He received his PhD from the Massachusetts Institute of Technology in the late 1970s and has worked with many professors who were once or are still involved with the center, including Mahmassani. "The BAC is the best assembly of industry-oriented folks broadly involved in the transportation world that has been set up by any university in the country," he says.

Before the Turek study, Philip worked with Karen Smilowitz, the William A. Patterson Junior Professor in Transportation and associate professor of industrial engineering and management sciences, and undergraduate students on two studies. One study looked at two locks on the Tennessee and Cumberland River systems to help gauge how barges should determine whether to divert from one river to another to avoid delays; the other looked at how many turn boats (a kind of towboat) Ingram should operate on the lower Mississippi River based on boat density in the river, costs, and benefits. "We provided a living laboratory that researchers could work in to study these problems," Philip says.

"Craig has been very supportive of the center and its activities and continues to be a leader both in industry and, in many ways, in how industry interacts with the academic community," Mahmassani says.

Philip says that industry likes being able to contribute to academic success. "We're able to participate in research projects stimulated by faculty members, so we can tap into the intellectual resources of the university and give back value to its academic success," he says.

Philip adds that giving the 2010 Patterson Lecture, an annual invited talk given by top transportation leaders, was "one of my proudest moments as a professional. To be able to add my name to the long list of very distinguished people who have given the lecture was amazing."

BRINGING IN YOUNGER COMPANIES

When Mahmassani came to Northwestern in 2007, he made it one of his missions to revitalize partnerships with industry. He recruited Bret Johnson as associate director for strategic relations and worked to broaden BAC membership.

One of his BAC recruits was Doug Waggoner, CEO of Echo Global Logistics, who joined the committee in 2009. Echo Logistics uses technology to analyze data from a network of 16,000 transportation carriers across industries, such as manufacturing and consumer products, to provide transportation savings for companies. The five-year-old Chicago company has enjoyed explosive growth — its first quarter of 2010 showed 82 percent growth over the first quarter of the previous year.

"Echo is almost like a poster child of new business models in transportation," Mahmassani says. "It has been very important to add companies like Echo, bring them into the fold, and keep our BAC reflecting emerging trends in industry. It has really brought new blood and excitement for our members."

When you're running a company, Waggoner says, it can be difficult

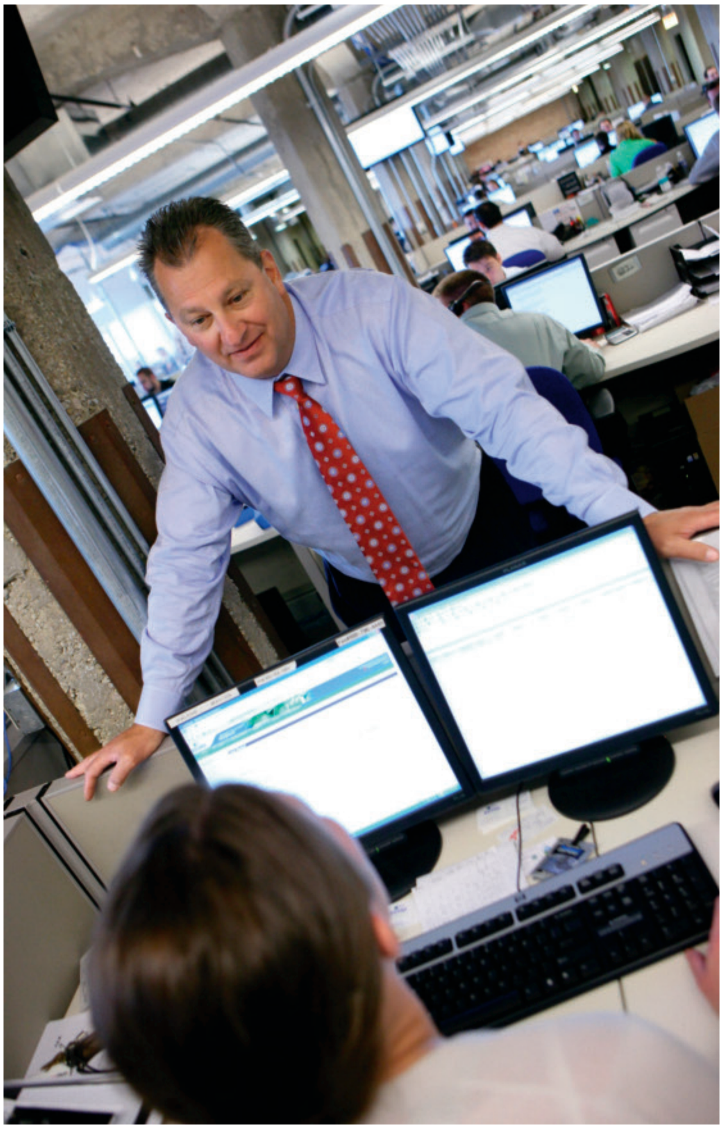
to step back from the day-to-day business objectives to take a broader view. "The BAC is a great networking opportunity," he says. "It gives me a chance to meet with people in academia and be exposed to the latest, greatest thinking."

Waggoner says since joining the BAC, he's been interested in faculty members' expertise in applying operations research to business problems. As a young company, Echo Logistics doesn't have the resources in place to conduct research in such areas as revenue optimization. "We deal with a massive number of transactions involving thousands of trucking companies," he says. "We're sitting on a huge amount of data, and we're not putting that data to work as well as we could. We need help evaluating it and looking for new ways to use that data to create algorithms and build better systems."

Echo Logistics' new business model — providing real-time information for its customers — presents challenging problems for researchers. Mahmassani and Waggoner are discussing a possible research partnership. "For professors like myself who have been working on problems of decision making in real time using real-time data, there's a lot of very exciting technical problems," Mahmassani says.

These industry connections benefit students as well, whether through undergraduate senior projects (such as the study with Smilowitz and her students) or through funding for dissertation research. BAC companies are frequent speakers on campus and heavily recruit Northwestern graduates. "One of the benefits is access to human capital," Waggoner says. "Echo has hired graduates from Northwestern. We're always on the lookout for talented young people, and we find them at Northwestern."

Mahmassani hopes to continue to strengthen industry connections even more. "We want to be partners in the exciting experiments that industry is engaging in," he says. "We want industry to think of the Transportation Center and Northwestern when they need people who think in new and creative ways, who can help them identify new technologies and methodologies. These partnerships are critical for us going forward, and it's through them that we will remain a unique center." M Emily Ayshford



CUTTING-EDGE RESEARCH

Student Dan Schuster discusses research on echocardiograph images with Dr. Kofo Ogunyankin. *Photo by Andrew Campbell.*

When undergrads are in the lab, everybody benefits

IF YOU HAD TO PICK A WORD TO DESCRIBE DAN SCHUSTER, IT WOULD BE "MOTIVATED."

Consider this image: Riding the University shuttle down to his research gig on the Chicago campus, Schuster dons a suit, clicks away on his iPhone, and shuffles through homework. The student next to him sleeps.

It's this motivation that got Schuster (biomedical engineering '11) a research position in the lab of Kofo Ogunyankin, assistant professor of cardiology at Northwestern's Feinberg School of Medicine, and it's this motivation that earned him a spot as a coauthor on published papers and as a speaker at an international cardiology conference.

"I realized quickly that research was what I wanted to do," Schuster says. "I wanted to go beyond the schoolwork and apply the knowledge I was learning."

Schuster is not alone in his pursuit of undergraduate research experience. Since 2005 the number of undergraduate researchers at McCormick has tripled. In the first four months of 2010 alone, 20 undergraduate researchers published papers. Over the past decade, McCormick undergraduates have coauthored more than 150 articles in more than 40 different journals and have participated in more than 65 academic conferences.

"At Northwestern we provide many activities for students outside the classroom: design opportunities, student government, sports," says Julio M. Ottino, dean of the McCormick School as well as a professor of chemical and biological engineering and mechanical engineering. "Those who choose to perform research have the opportunity to use both sides of their brain — to be both analytical and creative — and the results have been fantastic. Our undergraduate research program has grown exponentially in recent years, and everybody has benefited from it."

Undergraduates pursue research opportunities through work-study positions, for class credit, or even as volunteers. Some professors tape flyers around campus or post listings to the McCormick Undergraduate Research Society website; others snag students from their courses.

For Schuster, finding a position required persistence. During his first year at Northwestern, when most students were taking classes in search of a major, Schuster was already planning his postgraduate life. He knew he wanted to go to medical school (a hospital stay at age 10 to have his appendix removed convinced him he wanted to practice medicine), and he already had an interest in becoming an orthopedic surgeon. Despite having no research experience, he began sending e-mails to professors at Feinberg, looking for leads and asking if they needed any help in their labs. He pitched himself as a motivated freshman who, once trained, could provide them with four years of research work.

Ogunyankin answered the call. In his lab Schuster analyzes echocardiographic images — which are essentially sonograms of the heart — to help build a database for researchers to use in considering questions related to the function of heart ventricles. Schuster uses software to "speckle track" the echocardiographic images, analyzing the pixels to determine how the heart muscle is functioning. Since Northwestern Memorial Hospital's heart transplant program is considered one of the best in the world, many of the echocardiographs that Schuster analyzes are those of transplant patients.

"I've definitely been exposed to the reality of the medical field, like the taxing hours," Schuster says. "But I've developed my research skills, and that's something you just can't get in a classroom."

Schuster even got a chance to present his work at an American Society of Echocardiography conference in June 2009, the week before finals. "I was introduced as Dr. Schuster," he says. "I had to correct them. I didn't want to get thrown any tough questions! I felt a lot of pressure to prove myself, but it went well."

Schuster's experience has changed what he thought were concrete career plans. Now he wants to be a cardiothoracic surgeon who does both research and clinical work — a model he found in Ogunyankin. "I'd like to find a balance like Dr. Ogunyankin has," Schuster says. "Medicine is hard work, and it's a lot of time away from your family. But the exposure I've gotten has helped me decide that it's what I want to do."

Learning how research works

The research interests of Marissa Krotter (mechanical engineering '12) led her right to the top: the labs of Dean Ottino and Richard Lueptow, senior associate dean for operations and research and professor of mechanical engineering. As a scholar in the Murphy Institute (a program

that invites select McCormick undergraduates to engage in self-directed activities), Krotter had funding for a long-term research project, and she approached Ottino and Lueptow about working for them.

"I'm interested in fluid mechanics," she says. "I've always been interested in how things move based on different forces. So I looked around on professors' websites, and I liked what Deans Lueptow and Ottino were doing."

Krotter started out with easy tasks — like helping to organize items in the lab and updating chemical lists — that act as both a litmus test and a way to introduce students to lab life, Lueptow says. "These undergraduates are extremely talented, and their help extends what we can do in the lab. It's fun because they are so energetic and bright and are willing to ask naïve questions and do the routine work that needs to get done — and they do it better than we would!"

Krotter now spends 5 to 10 hours a week on her laptop, running programs that simulate a new kind of mixing called the cut-and-shuffle method, which mixes a material similarly to how cards are shuffled. Ottino's and Lueptow's experimental and theoretical research projects involve examining how fluids and granular materials mix, yielding applications for the geophysical sciences, medicine, microfluidics, materials processing, and nonlinear dynamics.

"Those who choose to perform research have the opportunity to use both sides of their brain — to be both analytical and creative — and the results have been fantastic."

JULIO M. OTTINO

The modeling that Krotter does requires her to write code in MATLAB, a high-level technical computing language and interactive environment for algorithm development. Her computational experiments quickly reached a level that allowed her to collaborate with a doctoral student in the Department of Engineering Sciences and Applied Mathematics, and her data could provide the basis for a mathematical theory that lies behind the mixing. "I have learned so much about the research process," she says. "I've never been involved with anything like this before. It has been a great opportunity to learn about what you actually do when you do research."

"One of the fun things about working with undergraduates," says Lueptow, "is that they really don't understand how research works yet. In high school they are trained in the scientific method, which isn't the way research is done. Instead it builds on previous research, and it's more curiosity driven than hypothesis driven. It didn't take Marissa long to understand that idea."

Krotter was acknowledged in a recent paper and plans to give a talk at a regional conference this fall. In the meantime, she continues to meet weekly with Lueptow, who considers the meetings "one of the highlights of my week."

"Marissa has been great," he says. "We know that our students are some of the best there are. Conducting research really provides them with benefits in the long run, no matter what career they choose."

Giving graduate students a chance to mentor

On any given day Mitra Hartmann, associate professor of biomedical and mechanical engineering, could have half a dozen graduate students and up to a dozen undergraduates working away in her lab. Hartmann's laboratory uses the rat whisker system as a model to study how the brain integrates tactile information with movement. The research requires students to learn a tremendous variety of skills, from numerical modeling to training rats to perform tactile discrimination tasks.

Because of the large number of students involved in research and the diversity of skills required, Hartmann and her graduate students have developed a mentoring system as efficient as the experiments themselves: as each graduate student progresses through the PhD program, he or she gradually assumes more responsibility for mentoring undergraduates. This helps ensure increased help for graduate students as their thesis projects become more complex and gives undergraduates high-quality research experiences.

"There is a significant time and resource investment in training undergraduate students," Hartmann says. "At least initially, it requires almost daily one-on-one interaction. Graduate students can provide that, and it gives them a chance to gain mentoring experience. In return, help from qualified undergraduates enables graduate students to expand the scope of their thesis projects. Undergraduates also allow the lab to explore higher-risk research avenues that we would not otherwise have the resources to explore."

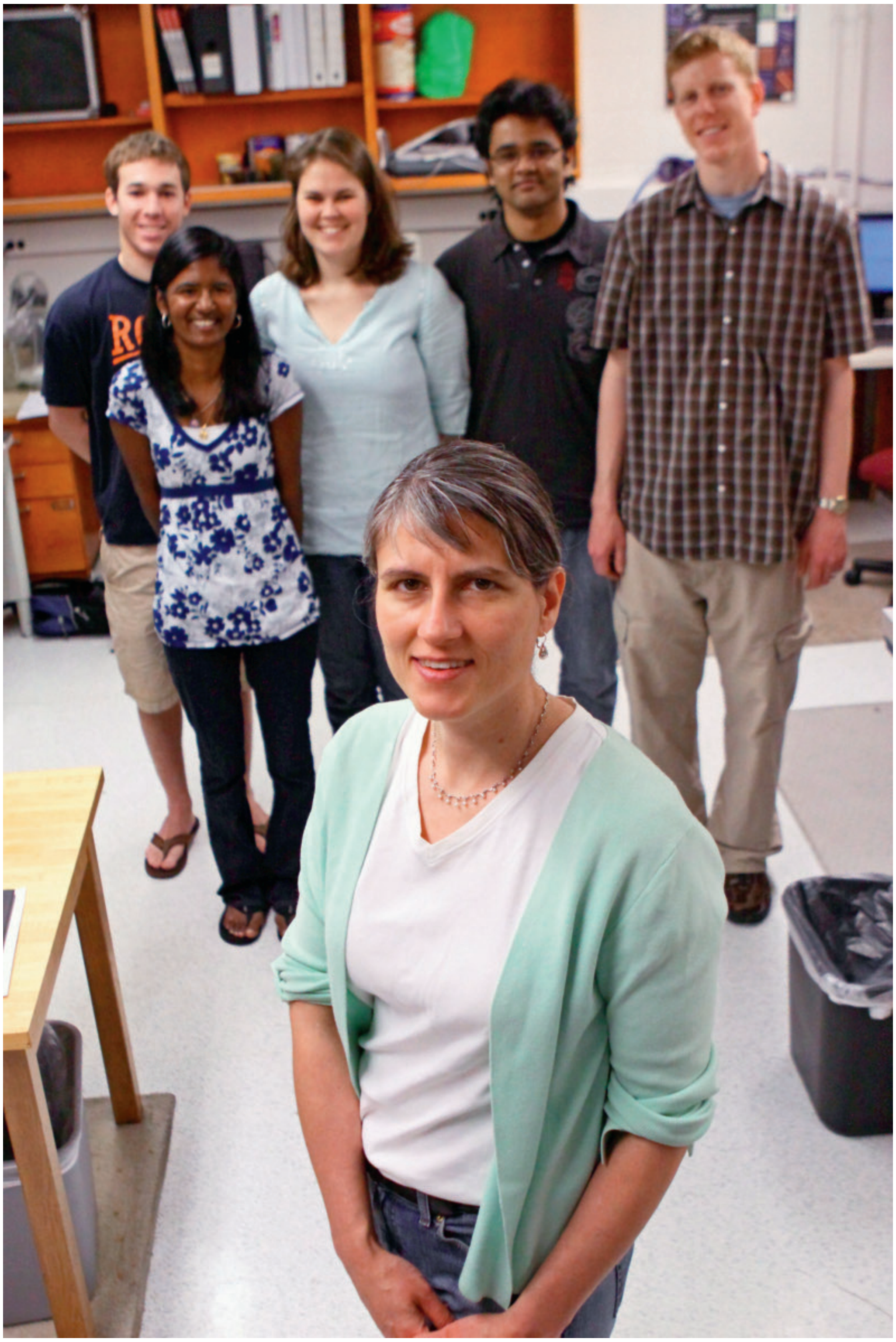
For graduate student Brian Quist and postdoc Blythe Towal, working with undergraduates provides both assistance with their work and a chance to practice their managerial skills. Towal has supervised undergraduates in the construction of laser light sheets she designed to detect whisker movements as well as on developing MATLAB code to process images from slow-motion videos of rats. Quist has managed

Left: Melissa Krotter talks about her recent findings with Rich Lueptow (middle) and Julio M. Ottino. Below: Mitra Hartmann with graduate and undergraduate students who work in her lab. *Photos by Andrew Campbell.*

undergraduate students in a project he designed to quantify whisker mechanical properties. "It's neat to be working with people to whom you can give concepts and ideas and have them follow through," Quist says. "The opportunity to manage these smart people is great."

One of those smart people is Samuel Protas (mechanical engineering '11), who has worked in Hartmann's lab with both Towal and Quist for a year. In his first six months Protas helped develop an algorithm to automatically track the movements of rat whiskers in video footage of rats performing behavioral experiments. In his second six months he designed a method to characterize the material properties of rat whiskers.

"By pursuing an undergraduate research experience I was able to get a kind of 'sneak preview' of a career in research," he says. "Whether it was image processing or programming from my first project, or the design and machining skills from my second, everything I did was practice for something I could end up doing with my life. It allowed me to become somewhat of an expert on these subjects, which is very satisfying. There's a feeling of accomplishment at the end that I just don't get from finishing a class project."



While the opportunities for undergraduate research at McCormick are plentiful, not everyone is cut out for it. Sometimes students'

"If you're driven by curiosity, research is an unmatched opportunity to pursue something in detail."

MITRA HARTMANN

skills aren't suited to the work. Some students can only commit to work in the lab for a quarter — which, in the world of research, isn't enough time to accomplish much.

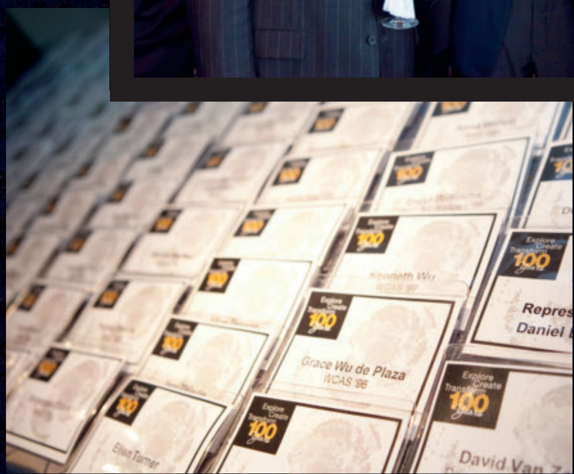
For those who do commit, however, the lessons are as much about tenacity as the project at hand. "It teaches undergraduates about what I like to call the 'time constant' of research," Hartmann says. "Undergraduate courses have deadlines or exams every few weeks. Research operates on a very different time scale. Ten weeks might be barely enough to get your first piece of data. Then, when you analyze the data, you might realize that you need to go back and do the experiment over."

"Things don't always work," Towal says. "Undergraduates can be uncomfortable with that. It's totally alien for them not to find an answer to the question they are trying to solve. It's good for them to have this experience."

Learning to take the skills they've gained in courses and combine them with creativity to solve a problem will help students immensely in their careers, Hartmann says. "If an undergraduate student is driven by genuine curiosity, research is an unmatched opportunity to pursue a question in detail," she says. "When experiments work and analysis shows a clear result, the feeling of accomplishment and moment of insight is brilliant." M Emily Ayshford

Centennial celebrations come to Washington …
McCormick joined Northwestern University School of Law in hosting a Centennial cocktail reception at the Newseum in Washington, DC, on April 28. The 150 attendees enjoyed food and drinks, excellent views of the nation's capital, and remarks from Dean Julio M. Ottino and David E. Van Zandt, dean of the School of Law.

Explore
Create
Transform
100 Years


Kenneth Wu
Repres
Daniel
Grace Wu de Plaza
WCAS '96
David Van Z


WHAT

... and New York

McCormick partnered with the Judd A. and Marjorie Weinberg College of Arts and Sciences to host the final Centennial celebration on May 13 at the Rubin Museum of Art in New York City. More than 100 attendees enjoyed the museum's collection of Himalayan art and heard remarks from Dean Julio M. Ottino and Sarah Mangelsdorf, dean of Weinberg College.

Research *by the numbers*

56
SPONSORS OF McCORMICK RESEARCH, INCLUDING FEDERAL AGENCIES, FOUNDATIONS, AND CORPORATIONS

113
PATENTS FOR McCORMICK INVENTORS SINCE 8/99

1,147,000
NET ASSIGNABLE SQUARE FEET OF NONCLASS LAB SPACE AT McCORMICK

501
NODES (COMPUTERS) IN QUEST, A SUPERCOMPUTING CLUSTER RANKED 236 IN THE TOP 500 COMPUTER SYSTEMS IN THE WORLD

$71,499,595
VALUE OF RESEARCH AWARDS RECEIVED IN 2010

308
NONCLASSROOM LABORATORIES (NOT INCLUDING SILVERMAN HALL)

30
RACKS OF COMPUTERS DEDICATED TO RESEARCH COMPUTING AT McCORMICK

20
START-UPS WITH AN ACTIVE LICENSE AGREEMENT WITH NORTHWESTERN

$451,965,779
TOTAL VALUE OF McCORMICK RESEARCH PROPOSALS IN FISCAL YEAR 2009

CLASS NOTES

1960s

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

John F. Carney III (MS '64, PhD '66), chancellor at the Missouri University of Science and Technology, received the Chief Executive Leadership Award from the Council for the Advancement and Support of Education.

Dennis H. Chookaszian ('65), retired chairman and CEO of CNA Insurance Companies, was elected to the board of directors of the Evanston-based direct marketing agency Leapfrog Online.

Paul F. DuMont ('65) retired after nearly 20 years as a faculty member at the Walsh University School of Business in North Canton, Ohio.

David J. Werner (MS '66, PhD '69), former chancellor of Southern Illinois University–Edwardsville, was named interim president of Indiana University of Pennsylvania.

Roger W. Ehrich (MS '67, PhD '69) was named professor emeritus of computer science at the College of Engineering at Virginia Tech by the school's board of visitors.

Robert P. Wayman ('67), retired executive vice president and CFO of Hewlett-Packard, received the 2010 Hall of Fame Lifetime Achievement Award from the independent selection panel for the Bay Area CFO of the Year Awards.

Peter Benjamin (PhD '68) was elected to lead the board of directors of Metro, the public transit administration of Washington, DC. He has held senior positions with the agency for 20 years.

William D. Ford (MS '68, PhD '71), the retired CEO of refining and marketing at BP, was elected a fellow of Notre Dame University.

1970s

Michael T. Abbene Jr. ('70), retired vice president and chief information officer at Arch Coal, was elected to the board of directors of Active Control Technology.

Burks Oakley II ('71), a visiting research professor at the Center for Online Learning, Research, and Service at the University of Illinois–Springfield, was named director of the New Century Learning Consortium.

Peter J. Barris ('74) is the managing partner of New Enterprise Associates, which has closed a $2.48 billion venture capital fund, the largest since the financial crisis.

Andrew Charles Fox ('75) was promoted from president to the newly created position of managing director at Pacific Harbor Line, a provider of railroad switching services. In addition, he has been named president and CEO of the Chicago South Shore & South Bend Railroad.

Michael D. Meyer (MS '76), a transportation expert, was appointed to an independent panel tasked with reviewing the Columbia River Crossing project, a joint effort of the Oregon Department of Transportation and the Washington State Department of Transportation.

Kevin John Gross ('77) was named president of the Oklahoma division of Ardent Health Services and CEO of Hillcrest HealthCare System. He was previously a senior vice president at RehabCare Group.

David L. Porges ('79) was promoted from president and COO to CEO of EQT Corporation.

1980s

Thomas Steven Buchanan (MS '82, PhD '86), a deputy dean in the College of Engineering at the University of Delaware, was appointed director of the university's Delaware Rehabilitation Institute.

Jeffrey S. Goldfinger ('82), director of business development at L-3 Communications Corporation, was named chairman of ASTM International Committee F38 on Unmanned Aircraft Systems.

George Ribarchik ('82) was promoted to director of product development of Fur Trim Inc., a leading supplier of the pet grooming industry. He is also publishing a children's book, *Johnny and Susie Visit the Oil Refinery,* which he hopes will inspire children to pursue careers in the exciting chemical engineering field.

Steven P. Riehs ('82) was appointed president of K–12, professional, and international education at DeVry Inc. He was previously president of DeVry Online Services.

Randolph L. Romenesko (MS '83), an engineering consultant in Nome, Alaska, has been reappointed to the Denali Access System Advisory Committee.

Curt J. Andersson ('84), formerly president of Cooper Crouse-Hinds, was appointed president of the North American tire business unit at the Goodyear Tire & Rubber Company in Akron, Ohio.

Scott P. Halstead ('85) was appointed CFO of Viator Inc., based in San Francisco. He was formerly CEO of Zane Benefits in Park City, Utah.

Vallerie V. Valentini ('85), professor of medicine and director of the Pulmonary Hypertension Program in the Division of Cardiovascular Medicine at the University of Michigan, received the Pulmonary Hypertension Association Award of Excellence in Pulmonary Arterial Hypertension Care.

Gill Roy Eapen (MS '86) was appointed vice president of life sciences at Charles River Associates, a management, economic, and financial consulting firm.

Timothy O. Odi (MS '86, PhD '90), an engineering fellow at Chevron Phillips Chemical Company, was named a fellow of the American Institute of Chemical Engineers.

James G. Conley (PhD '87), professor of mechanical engineering at McCormick, clinical professor of technology industry management at the Kellogg School of Management, and visiting professor at WHU — Otto Beisheim School of Management in Vallendar, Germany, was appointed to the Trademark Public Advisory Committee in the US Department of Commerce's Patent and Trademark Office.

Katrina L. Helmkamp ('87) was named CEO of SVP Worldwide, a sewing machine manufacturer. She was previously a senior vice president for Whirlpool.

Michael S. Kryza Jr. ('88) was promoted from executive vice president in the life insurance services division to executive vice president of corporate development at Crump Group Inc.

Jacob Fish (PhD '89), the Rosalind and John J. Redfern Chaired Professor of Engineering at Rensselaer Polytechnic Institute, was awarded the Computational Mechanics Award by the International Association of Computational Mechanics.

Jyoti S. Thombre (MS '89), most recently general manager of Alcatel-Lucent's next-generation networks product unit, was appointed head of the company's New Zealand operations.

1990s

Lt. John V. Bills, USN ('91), is a director in the New York office of Credit Agricole.

David Albert Lange (PhD '91), professor of civil and environmental engineering at the University of Illinois at Urbana-Champaign, was appointed chair of the American Concrete Institute's Technical Activities Committee.

Daniel J. Schwartz ('92) was named a partner in the intellectual property practice group at Seyfarth Shaw. He was previously an attorney with Jenner & Block.

Brion S. Collins ('93) is an investment adviser representative with NEXT Financial Group Inc. He received the Five Star Wealth Manager Award for 2010, based on client and industry professional evaluations and given to wealth managers in the Milwaukee area.

Sadhan C. Jana (PhD '93), professor and chair of the University of Akron's department of polymer engineering, received the Education Award for lifetime achievement from the Society of Plastics Engineers.

John P. Sheputis (MEM '93) is the founder and CEO of Fortune Data Centers in San Jose, California.

Daniel B. Oerther ('95) joined the faculty at the Missouri University of Science and Technology. He was previously professor of environmental engineering at the University of Cincinnati.

Aimee L. Vessell ('95) is manager of international projects at Harley-Davidson.

Thomas Adam Kolaja (MEM '96) was appointed managing director and head of the restructuring practice in the newly opened Warsaw, Poland, office of Alvarez & Marsal.

Elizabeth Carol Dickey (PhD '97) will become dean of the Edward E. Whitacre Jr. College of Engineering at Texas Tech University in January 2011. She has been a professor of materials science and engineering at Pennsylvania State University.

Alexander G. Agrios (MS '98, PhD '03) is an assistant professor of environmental engineering at the University of Connecticut, where his research focuses on developing solar energy technologies to prevent environmental pollution.

Nirav A. Shah ('98) is an orthopaedic sports medicine surgeon affiliated with Palos Community Hospital in Palos Heights, Illinois. He is credited as the first physician to develop a new nanotechnology biomedical therapy for use in the treatment of joint injuries.

Samir Shah ('98, MS '03) was appointed senior vice president and chief risk officer at insurance provider Chartis. He was formerly executive vice president and chief risk officer at Validus Holdings.

Marcus R. Elliott ('99) was hired by BergerABAM in Federal Way, Washington, as an engineer.

Kolluru V. Subramaniam ('99), associate professor of civil engineering at the City College of New York Grove School of Engineering, was named a fellow of the American Concrete Institute.

2000s

Mark A. Ahasic ('00), formerly senior manager of aviation consultancy Simat Helliesen & Eichner Consulting and JetBlue Airways, was appointed vice president of business development and strategic planning at CLEAR, a registered travel program.

Alexander M. Eliashevsky ('00), formerly an equity options trader at the Chicago Board of Options Exchange, was appointed manager of mergers and acquisitions and a director at Brand Neue Corporation.

Eva M. McGoey ('00) is senior office manager and CIO of Health Care Service Corporation. In early 2010 she shared her experiences in a math- and science-oriented career with a group of female high school sophomores at an event sponsored by Illinois Tool Works and Glenbrook South High School.

Shawn Wischmeier (MEM '02), previously chief investment officer of the Indiana Public Employees' Retirement Fund, was named chief investment officer for North Carolina's $68 billion pension fund.

Brian A. Hannah ('03) was promoted from senior writer to director of science and clinical support at Chicago-based health care communication agency Goble & Associates Inc.

Katherine Natalie Radwanski ('06, MS '07) is a biomedical engineer at medical technology company Fenwal Inc. She received a Junior Investigator Award from the American Society for Apheresis.

Antonio Roy Webb (MS '06, PhD '08), cofounder, senior scientist, and lead development engineer of VesselTek, was named the 2010 Ewing Marion Kauffman Foundation Emerging Postdoctoral Entrepreneur.

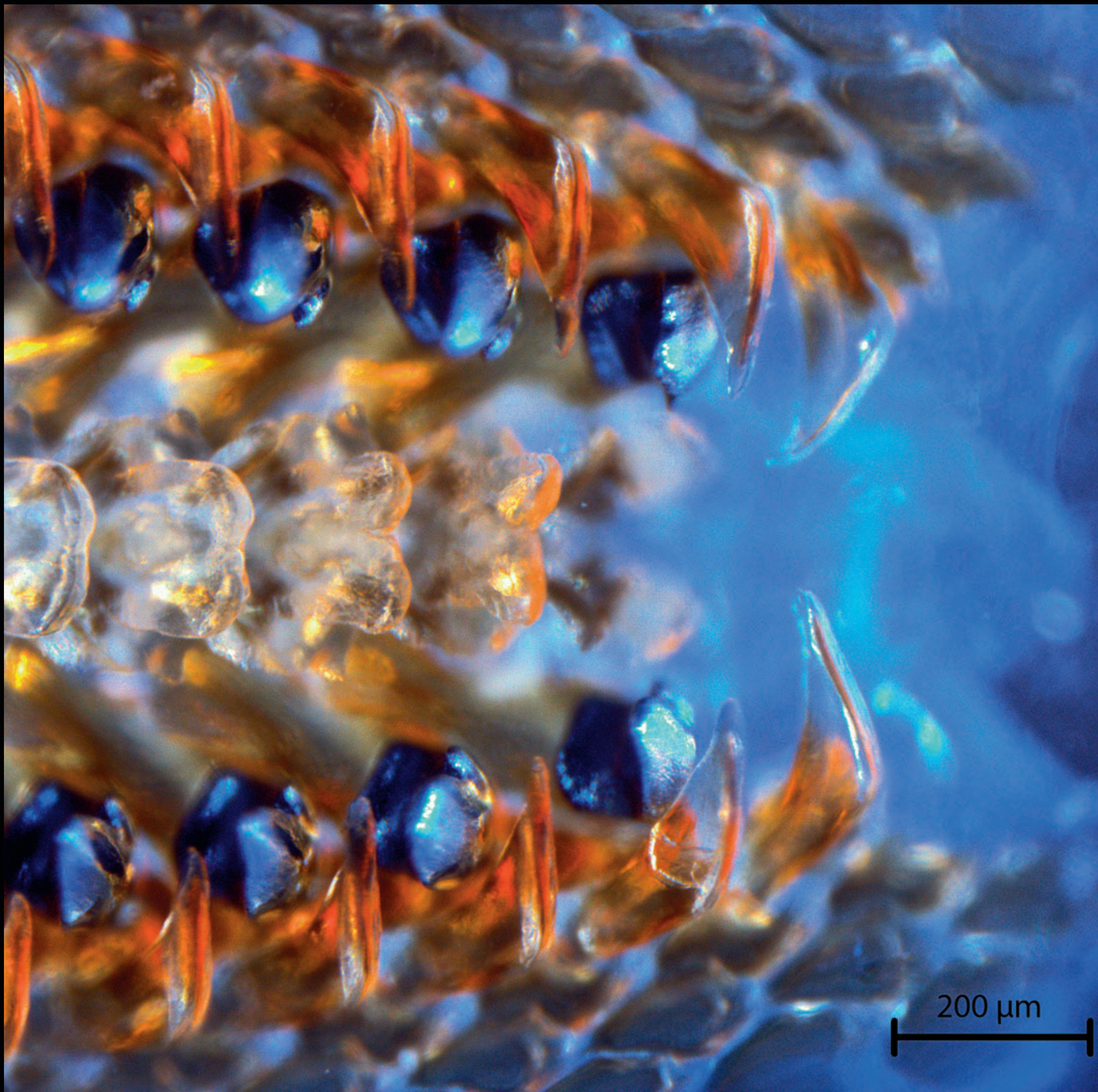
Sandra Lee Waters (MEM '07) was named COO of the Federation of State Medical Boards.

2010s

Ritu Gopal ('10) was named one of the top 50 Illinois technology students of 2010 by the Illinois Technology Foundation.

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 front section of the radula (tongue-like organ) of an Eastern beaded chiton, a kind of marine mollusk. The chiton, which constantly grazes algae from the surface of rocks, constructs these small black teeth along the radula from ultrahard nanocrystalline iron oxide (magnetite). Although these teeth are one of the hardest minerals found in biology, they still wear out, and the organism constantly replaces them with new teeth at a rate of nearly one row per day.

This image, captured in a reflected-light stereomicroscope, is courtesy of Derk Joester, assistant professor of materials science and engineering and Morris E. Fine Professor of Materials and Manufacturing, and his graduate student Lyle Gordon. The researchers are studying how the chiton controls the formation of the teeth.

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McCormick's class of 2010 celebrates the end of the school's Centennial.