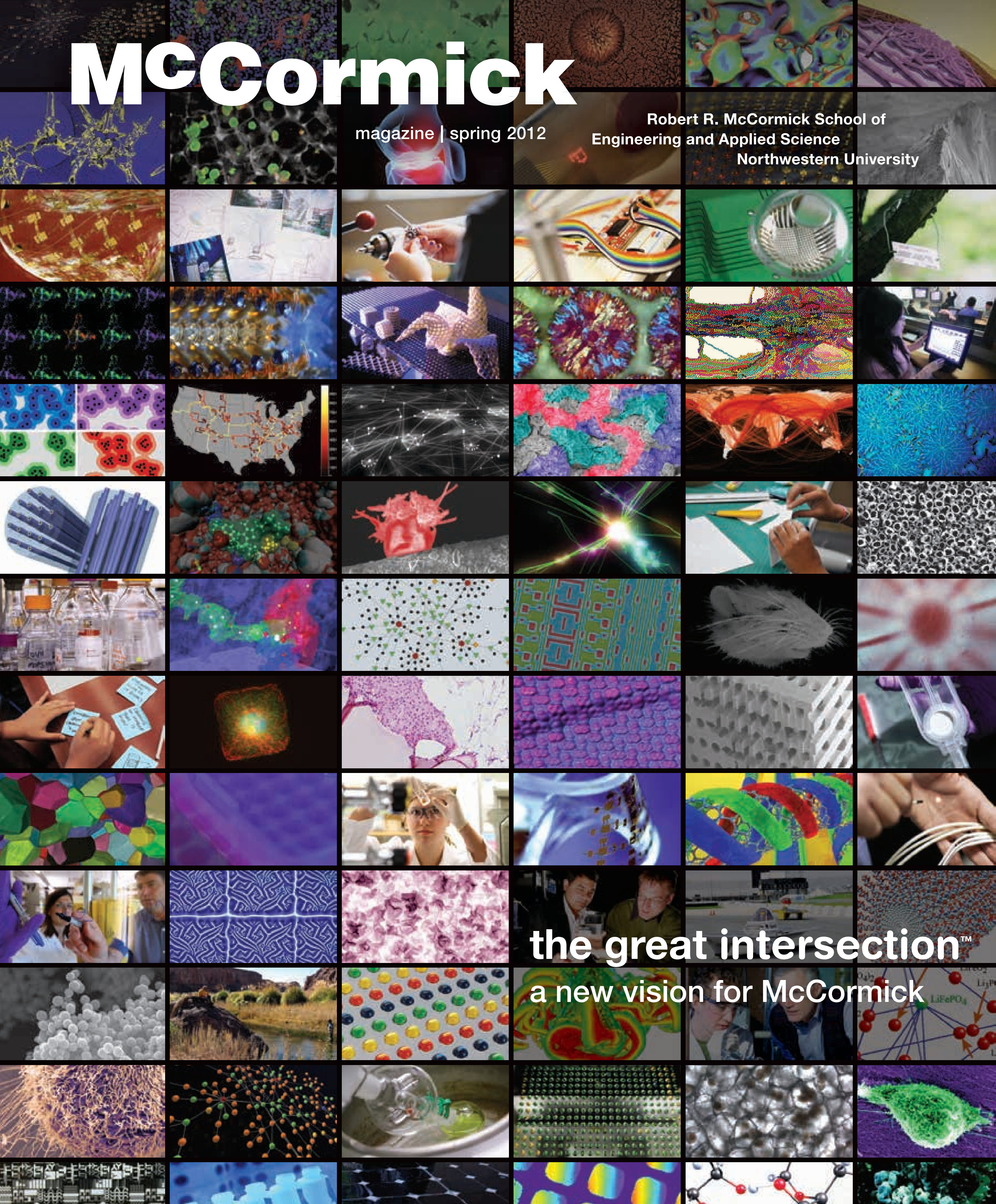
McCormick

magazine | spring 2012

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



the great intersection™

a new vision for McCormick

FROM THE DEAN

Greetings from McCormick.

We live in an exciting time. Our world is changing rapidly, and engineering is at the forefront of that change. At the same time, we face global challenges of a scale never before seen. This reality has led us to rethink the positioning of McCormick and the role that we play in addressing global challenges.

I am pleased to share in this issue our new vision for McCormick: **The Great Intersection.** The intersection of global challenges and the knowledge required to solve them provides a framework for communicating both the progress that our school has made and our path forward.

We have identified five strategic priorities, or areas of emphasis, for the future of McCormick: energy and environment, health and wellness, systems, materials, and creating leaders. The first four represent areas of research emphasis; the fifth, creating leaders, is at the core of our priorities for McCormick.

In addition to a sampling of our efforts within these five strategic areas, this issue also features faculty members whose research is funded by industry—a growing source of revenue in the ever-changing funding landscape. More than 10 percent of research at the school is now funded by corporate sponsors that provide funding in strategic areas while giving graduate students and faculty freedom to conduct basic science research. These agreements also give our students and faculty connections with their peers in industry, which has led to innovations and jobs for graduates. We have helped streamline this process at the University to encourage more of these partnerships.

We are also pleased to feature two exceptional students, Sam Malin and Aaron Stebner, who embody McCormick's goal of educating whole-brain engineers, and we showcase several outreach projects—including our annual Career Day for Girls, when students and faculty come together with middle and high school girls to demonstrate what it means to be an engineer.

I hope you will take some time to explore this magazine and our website to learn more about how we think and where we are going.

As always, I welcome your feedback.

Julio M. Ottino, Dean | May 2012

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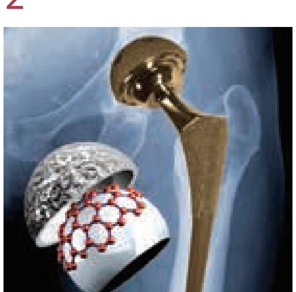

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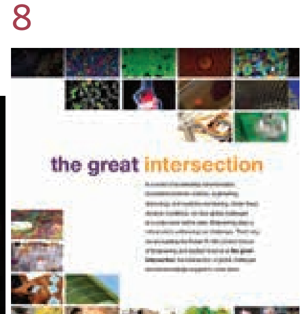

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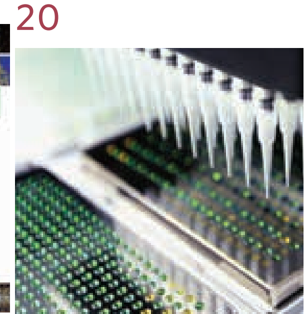

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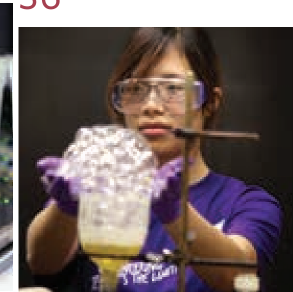

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McCormick news

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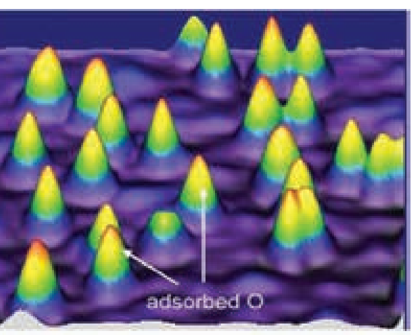
A STEP TOWARD BETTER ELECTRONICS



Researchers at McCormick have developed a method for chemically altering graphene that could pave the way for faster, thinner, and more flexible electronics.

Graphene is a one-atom-thick, honeycomb-shaped lattice of carbon atoms with exceptional strength and conductivity. Many experts believe it could transform integrated circuits and lead to ultrafast computers, cellphones, and related portable electronic devices. But first researchers must learn how to tune the electronic properties of graphene.

That's not an easy feat: unlike semiconductors made of silicon, pure graphene is a zero-band-gap material, making it difficult to turn off the electric current that flows through it. Therefore, pure graphene is not appropriate for the digital circuitry in the vast majority of integrated circuits. To overcome this problem, researchers around the world are investigating methods for chemically altering the material. The most prevalent strategy is the Hummers method—a process that oxidizes graphene through the use of harsh acids that irreversibly damage the fabric of the graphene lattice—but the resulting material is difficult to control.

Researchers at McCormick, led by **Mark C. Hersam,** professor of materials science and engineering, chemistry, and medicine, have developed a method to oxidize graphene without the collateral damage produced in the Hummers method. "Our method produces graphene oxide that is chemically homogeneous and reversible, leading to well-controlled properties that likely can be exploited in high-performance applications," Hersam says. "It's unclear whether this work will impact real-world applications overnight, but it appears to be a step in the right direction."

The research was published in the journal *Nature Chemistry.*

Next, researchers will explore other means of chemically modifying graphene to develop a wider variety of materials, much as scientists did for plastics in the last century. "Through chemical modification," Hersam says, "the scientific community has developed a wide range of polymers, from hard plastics to nylon. We hope to realize the same degree of tunability for graphene."

The National Science Foundation, the Office of Naval Research, and the US Department of Energy supported this research.

RESEARCH MAY LEAD TO LONGER-LASTING HIP JOINTS

Researchers from McCormick, Rush University Medical Center in Chicago, and the University of Duisburg–Essen in Germany have identified a key element of the naturally occurring lubricating layer that develops on metal-on-metal hip implants. This discovery changes our understanding of how hip implants work and suggests new types of implants that can better resist wear and tear.

Prosthetic materials for hips, such as metals, polymers, and ceramics, typically last about 10 years. Physicians would love to increase that lifespan to 30 to 50 years—ideally, the patient's lifetime. "Metal-on-metal implants can vastly improve people's lives, but it's an imperfect technology," says **Laurence D. Marks,** a professor of materials science and engineering. "Now that we are starting to understand how lubrication of these implants works in the body, we have a target for how to make the devices better." Marks led the experimental effort at Northwestern and was a coauthor of the study, published in the journal *Science.*

Earlier studies showed that friction between metallic joints causes the formation of a lubricating layer that lessens friction between implants and reduces wear and corrosion. No one knew what this tribological layer was made of until researchers from McCormick and the other institutions studied implants retrieved from patients. They found a well-known atomic fingerprint of graphitic carbon in the tribological layer that formed on the metal parts. Along with other evidence, this discovery led them to conclude that the layer consists primarily of graphitic carbon, a well-known solid lubricant.

"Knowing that the structure is graphitic carbon really opens up the possibility that we may be able to manipulate the system to produce graphitic surfaces," says Alfons Fischer of the University of Duisburg–Essen. "We now have a target for how we can improve the performance of these devices."

"Hip-replacement surgery is the greatest advance in the treatment of end-stage arthritis in the last century," says Joshua J. Jacobs of Rush University Medical Center, the study's principal investigator and a 1977 McCormick alumnus. "Our findings will help push the field forward by providing a target to improve the performance of hip replacements."

The next phase, Jacobs says, is to examine the surfaces of retrieved devices and correlate the researchers' observations of the graphitic layer with the reason for removal and the overall performance of the metal surfaces. Marks also hopes to learn how graphitic debris from the implant might affect surrounding cells.

McCORMICK TEAM ROMPS IN SYNTHETIC BIOLOGY CONTEST

Last fall a team of Northwestern students took top honors at a regional synthetic biology competition of the International Genetically Engineered Machine (iGEM) Foundation. The team—**Valerie Chen** (biomedical engineering '13), Nirmit Desai (biological sciences '13), **Rafay Faruqi** (biomedical engineering '12), Kristin Palarz (biological and integrated sciences '14), **Helen Shen** (biomedical engineering '12), and **Michael Sherer** (biomedical engineering '13)—used *E. coli* to design a biosensor that can detect *Pseudomonas aeruginosa,* a common bacterium that thrives in hospitals and can cause pneumonia, gastrointestinal infections, and skin lesions. Seeking a faster, cheaper alternative to current *Pseudomonas*-detecting technology, the students took genes used in the quorum-sensing system of *Pseudomonas* and transferred them into *E. coli* so that the *E. coli* would fluoresce upon contact with auto-inducer molecules unique to *Pseudomonas.*

Last October the team competed against 70 other teams at iGEM's regional competition for North and South America. In addition to their *E. coli* project, the McCormick team presented a generalized math model for quorum sensing that would allow its work to be applied not just to *Pseudomonas* but to other pathogens as well. "Eventually you could have a one-size-fits-all detector for multiple pathogens," Faruqi says.

The judges were impressed by the math model, and Northwestern's team won a gold medal. The team also received the honor of Best Model in the Americas.

The iGEM project is advised by **Joshua Leonard, Michael Jewett,** and **Keith Tyo,** assistant professors of chemical and biological engineering; **Nichole Daringer,** a graduate student in chemical and biological engineering; and John Mordacq, distinguished senior lecturer in biological sciences.

JANSE TO DIRECT NEW BUSINESS VENTURES

The McCormick School and Northwestern's Innovation and New Ventures Office (INVO) have named **Michael Janse** director of new business ventures. In this newly created position shared by McCormick and INVO, Janse will lead efforts to identify promising technologies and educate and assist faculty and students in the commercialization process.

"Michael will help increase the value of Northwestern inventions by advancing them to the proof-of-concept stage and then to potential business ventures," says Alicia Löffler, executive director of INVO and associate vice president of research.

Janse has focused on investing in early-stage technology throughout his career. He founded a semiconductor technology start-up with a university researcher and held positions with the Harris & Harris Group, an advanced materials-focused venture capital firm in Palo Alto, California; ARCH Venture Partners in Chicago; and Motorola's Semiconductor Products Sector. He holds an MBA from the University of Chicago and a BS in chemical engineering from Brigham Young University.

"Innovations that never leave the lab cannot help solve global challenges," says Julio M. Ottino, dean of McCormick. "We are excited to have Michael augment the activities encompassed by INVO and the Farley Center for Entrepreneurship and Innovation."

ANALYTICS MASTER'S PROGRAM DEBUTS NEXT FALL

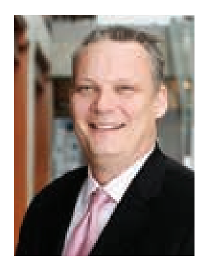
The demand for workers skilled in data analytics is skyrocketing in today's marketplace. To prepare students for this growing field, McCormick will introduce a master's degree program in analytics in the fall.

Housed in McCormick's Department of Industrial Engineering and Management Sciences, the 15-month MSiA program will combine math and statistics with instruction in advanced computational and data analysis. It is designed to allow recent graduates in engineering, science, or business to start their careers from a position of strength. The program will give students unprecedented access to faculty and resources and a place in a professional network when they graduate.

Under the guidance of faculty and prominent industry leaders, MSiA students will learn to identify patterns and trends; interpret vast quantities of structured and unstructured data; and communicate their findings in practical terms. Each student will complete an internship and a capstone project with an industry partner. Graduates of the program may go on to become analysts for Fortune 500 firms, statistical modeling or communications and media analysts, consultants, or systems engineers.

"We conceived this program because we recognized that there aren't enough trained individuals in this rapidly growing field," says **Diego Klabjan**, associate professor of industrial engineering and management sciences and director of the MSiA program. "McCormick is at the cutting edge of analytics, and we are looking forward to starting the program next fall."

NEW LEADERSHIP AT SEGAL DESIGN INSTITUTE



McCormick Dean Julio M. Ottino has announced new leadership and a revised administrative structure for the school's Segal Design Institute. **Greg Holderfield** (top), currently codirector of the MMM Program and clinical associate professor of mechanical engineering, has been named director of the institute, with **Bruce Ankenman** (bottom), professor of industrial engineering and management sciences, serving as codirector.

In a further change, the institute will now be advised by two faculty councils. An education council will oversee existing curricular activities and develop new initiatives. A research council will advise on the development and allocation of PhD fellowships and start-up grants for design research and create new initiatives to expand the academic field of design. These councils will consist of people throughout the University engaged in creative and scholarly activities associated with the institute's mission and may evolve into think tanks for creative idea generation within Northwestern.

"Northwestern's strategic plan articulates a clear emphasis on design and innovation among University priorities," says Holderfield. "The Segal Design Institute will be the hub for activities in this area and will continue to produce students who can connect disciplines to create impact."

The Segal Design Institute was founded in 2007 following a gift from Crate & Barrel cofounders Gordon and Carole Segal.

McCormick
IN THE MEDIA

WALL STREET JOURNAL OPINION PIECE COAUTHORED BY JULIO M. OTTINO

An op-ed written by **Julio M. Ottino,** dean of the McCormick School, and Mark P. Mills, a physicist, founder of the Digital Power Group, and McCormick Advisory Council member, was published in the *Wall Street Journal* in January. In "The Coming Tech-led Boom," Ottino and Mills name three breakthroughs that promise to transform this century much as electricity, telephony, stainless steel, radio amplifiers, and automobiles transformed the last one. "In January 2012 we sit again on the cusp of three grand technological transformations with the potential to rival that of the past century. All find their epicenters in America: big data, smart manufacturing, and the wireless revolution," the piece states.

MALCOLM MacIVER: SCIENTIFIC ADVISER TO THE STARS

When **Malcolm MacIver** isn't teaching or conducting research on robotic models and large-scale simulations of animal behavior, he works as a scientific adviser to Hollywood. After working on the movie *Tron: Legacy* and the television show *Caprica,* MacIver has a better idea of how the industry works. "Story creators might think scientists are geeks, but there's a sense of respect," MacIver told *Popular Mechanics* magazine in January. "That respect is not always there in the other direction. Scientists feel that filmmakers dumb down everything to make a buck."

BACKMAN FEATURED IN *NATURE* AS A TOP NIH GRANT AWARDEE

Vadim Backman was featured in a February article in *Nature* as one of seven scientists who receive the most grants from the National Institutes of Health. Backman, professor of biomedical engineering, has received more than $3 million from the NIH to support his lab of 20 students. While the NIH is instituting a new policy requiring researchers who control more than $1.5 million in grants to undergo an extra review before further grants are approved, Backman doesn't mind. He says competition among established researchers should be based on the strength of their ideas. "I like the idea of meritocracy," he says in the article.

BIOMEDICAL ENGINEERING PROFESSOR FEATURED IN *NEW YORK TIMES*

Julius Dewald, professor of biomedical engineering and professor and chair of physical therapy and human movement science at the Feinberg School of Medicine, was featured in a *New York Times* article in January that highlighted his work in understanding strokes and developing rehabilitation robotics.

"Dr. Julius Dewald is trying to meld medicine, science, and engineering in a pathbreaking way to better understand such impairment and how robotic therapy might help people who have had strokes reach for a hamburger or pull on a fancy boot," the article states.

Dewald uses EEGs and fMRIs to understand how joint control is linked to brain hemispheres after a stroke. His group has also developed robotics that can support the weight of a limb affected by a stroke, making it seem lighter and therefore requiring fewer brain signals to move. "Dr. Dewald's team just concluded a pilot study with 10 patients and is starting a second with 20," the article states. "A comprehensive clinical trial would follow. The goal is to produce robotic devices that cost less than $15,000, affordable for small clinics and some individuals."

SENIOR AMONG "15 WOMEN TO WATCH IN TECH"

Hannah Chung (mechanical engineering '12) has been named one of "15 Women to Watch in Tech" by *Inc.* magazine. Chung is one of the cofounders of Design for America, a Northwestern student initiative that aims to effect social change through interdisciplinary design. "With a background in engineering and art, 22-year-old Chung is passionate about making the world a better place," the article states. Among her creations with the group is Jerry the Bear with Diabetes (designed with Aaron Horowitz), an interactive robotic toy for children with type 1 diabetes. DFA has expanded to eight universities since its founding in 2009, and Jerry the Bear will soon be used in clinical trials.

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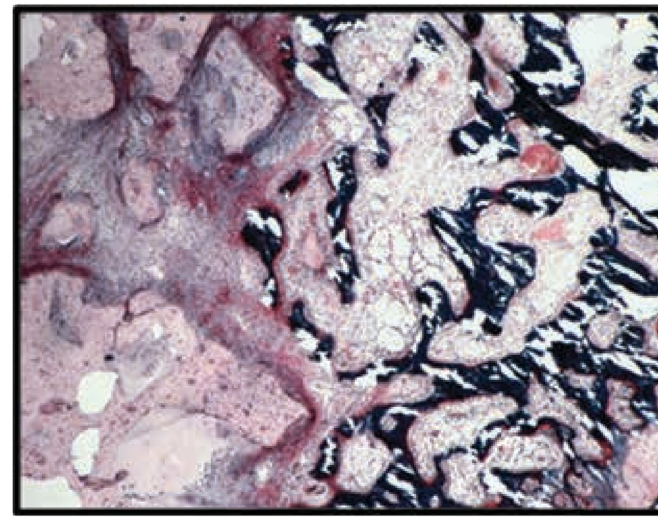


METAMATERIAL BOOSTS POTENTIAL OF SOLAR CELLS

Solar power may be on the rise, but solar cells are only as efficient as the amount of sunlight they collect. Under the direction of a new McCormick professor, researchers have developed a material that absorbs a wider range of wavelengths and could lead to more efficient and less expensive solar technology.

"To capture light most efficiently, a solar cell needs to have a broadband response," says **Koray Aydin,** assistant professor of electrical engineering and computer science and lead author of a paper that appeared in the journal *Nature Communications.* "This design allows us to achieve that."

The researchers used metal and silicon oxide to create thin but complex trapezoidal metal gratings on the nanoscale (shown below) that can trap a wider range of visible light. These materials achieve very high absorption rates, Aydin says, due to local optical resonances that cause light to spend more time inside the material until it gets absorbed. They also collect light from many different angles—a useful quality when dealing with sunlight, which hits solar cells at different angles as it moves throughout the day. If applied to semiconducting materials, the technology could lead to thinner, less expensive, and more efficient solar cells.

Aydin came to McCormick from the California Institute of Technology, where he was a research scientist in applied physics and materials science. His research was supported by the Department of Energy's Light-Material Interactions Energy Frontier Research Center, where Aydin was assistant director. Aydin received his BS and PhD in physics from Bilkent University in Ankara, Turkey.

Aydin was drawn to Northwestern because of its collaborative work environment and proximity to unmatched facilities, such as Argonne National Laboratory. "When I interviewed at McCormick, I met with not only the electrical engineering faculty but also members of the materials science faculty," Aydin says. "That showed me how much the school values collaboration and interdisciplinary interactions."

NEW SCAFFOLDS FOR TISSUE ENGINEERING

Northwestern researchers have developed an improved method for creating the scaffolds that are key to tissue engineering. These artificial lattice-like structures provide a template to support growing cells and over time are absorbed into the body, leaving behind only living tissue. Scaffolds are typically engineered with pores that allow cells to migrate throughout the material. But current methods have various drawbacks, such as creating imperfect pore structures and requiring lengthy processing, says **Guillermo Ameer,** professor of biomedical engineering and surgery.

The improved scaffolds developed by Ameer and his colleagues are created from a combination of ceramic nanoparticles and elastic polymers. These new scaffolds are highly flexible and can be tailored to degrade at varying speeds, depending on the expected recovery time of patients. The scaffolds (shown above) can also incorporate nano-sized fibers, providing a new range of mechanical and biological properties. "The technology could prove very useful in repairing anterior cruciate ligament tears and in bone-void fillers," Ameer says.

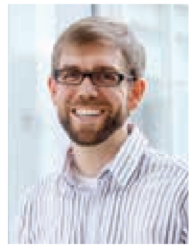
A paper describing the research was featured in the journal *Tissue Engineering.*

McCORMICK FACULTY AWARDS

Wesley Burghardt, professor of chemical and biological engineering and Charles Deering McCormick Professor of Teaching Excellence, was elected a fellow of the American Association for the Advancement of Science, the world's largest general scientific society. He was cited for his development of pioneering optical and X-ray scattering methods used to study the structural dynamics of polymers during flow and processing. His research emphasizes in situ investigation of flow-induced structural changes to elucidate the origins and mechanisms of complex rheology in polymers.

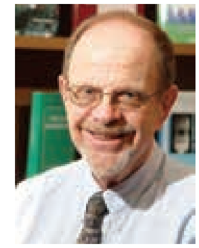
Ken Forbus, Walter P. Murphy Professor of Electrical Engineering and Computer Science, has received a Humboldt Research Award from the Alexander von Humboldt Foundation in Germany. The award is given to academics whose fundamental discoveries, new theories, or insights have had a significant impact on their disciplines and who are expected to continue their cutting-edge achievements. Forbus's areas of expertise include qualitative reasoning, spatial reasoning, analogical reasoning and learning, learning from natural language, and inference engine design.

Nicole Immorlica, assistant professor of electrical engineering and computer science, received a Sloan Research Fellowship. She is one of 126 outstanding early-career scientists and scholars recognized by the Alfred P. Sloan Foundation this year. Immorlica's research interests lie in the structure, formation, and design of social networks and problems at the intersection of game theory and algorithms. Understanding the theoretical properties underlying networks and the incentives they introduce is fundamental to creating well-designed and functioning systems.



Michael C. Jewett, assistant professor of chemical and biological engineering and a member of the Chemistry of Life Processes Institute and the Robert H. Lurie Comprehensive Cancer Center of Northwestern University, has been awarded a Packard Fellowship for Science and Engineering by the David and Lucile Packard Foundation. Jewett, a synthetic biology expert, is among the 16 promising science and engineering researchers nationwide to receive an unrestricted research grant of $875,000 over five years. With his Packard Foundation funding, Jewett will advance his research on developing cell-free synthetic biology for speedy, on-demand biomanufacturing of new classes of lifesaving drugs, sustainable fuels, and novel materials from renewable resources.

John Rudnicki, professor of civil and environmental engineering and mechanical engineering, received the 2011 Daniel C. Drucker Medal from the American Society of Mechanical Engineers. The society honored Rudnicki for providing a new understanding of deformation instabilities in brittle rocks and granular media, including their interactions with pore fluids, with applications to fault instability, quantification of energy radiation from earthquakes, and environment- and resource-related geomechanics.



Joseph L. Schofer was named a national associate by the National Research Council of the National Academies. Schofer, an expert in the planning and management of transportation systems, is professor of civil and environmental engineering, associate dean for faculty affairs, and director of the Infrastructure Technology Institute. The honorary title is bestowed on people with an "extraordinary dedication" to the National Academies. Schofer, who has taught at McCormick since 1970, is active on the Transportation Research Board of the National Research Council, where he has chaired policy studies, taken part in committees and task forces, and served in numerous leadership roles since 1968.

Randall Q. Snurr, professor of chemical and biological engineering, was elected a fellow of the American Association for the Advancement of Science, the world's largest general scientific society. He was honored for advancing the application of nanoporous metal-organic frameworks in energy storage and separations as well as for showing the power of molecular simulation to design new materials. Snurr is particularly interested in the development of nanoporous materials to solve environmental and energy problems.

STUDENT TEAM WINS BIG IN BUSINESS COMPETITIONS

NuMat Technologies, a start-up comprising three Northwestern graduate students and a research professor, has won nearly $1 million this year in two prestigious competitions. In March it won $100,000 in the Clean Energy Challenge, an annual competition that awards prizes to top Midwest clean-technology entrepreneurs. In April it won four awards—including the grand prize—worth $874,000 in the Rice Business Plan Competition, the world's richest and largest graduate-level business plan contest.

NuMat Technologies developed a computational screening tool to rapidly identify and test metal-organic frameworks (MOFs), crystals with nanoscopic pores and incredibly high surface area that can be used for the storage of gases. It created algorithms able to generate large databases of hypothetical MOFs tailored to address specific problems, and it designed technologies to streamline the development of these materials. The process was developed in the lab of **Randall Q. Snurr,** professor of chemical and biological engineering. (See related story on page 10.)

"A major challenge today is figuring out a way to store fuels that are clean and eco-friendly," says Chris Wilmer, a graduate student in chemical and biological engineering. "We've developed a plan to identify the right materials to store clean fuels, synthesize them, test them, and produce them on a large scale for industry."

In addition to Wilmer (far right), members of NuMat Technologies include (from left) research associate professor Omar Farha, graduate student Tabrez Ebrahim, and graduate student Ben Hernandez.

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TWO ELECTED TO THE NATIONAL ACADEMY OF ENGINEERING

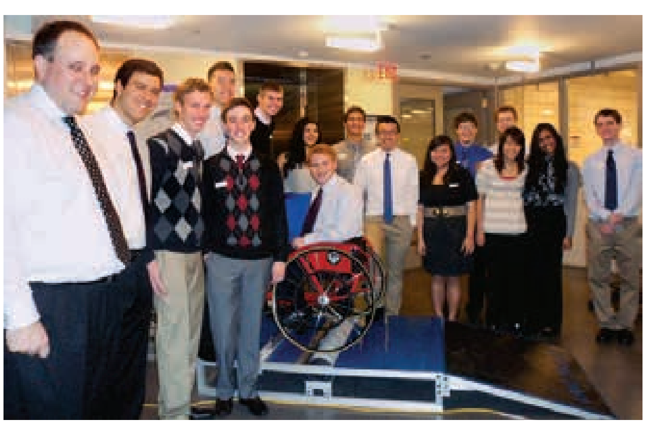
Tobin J. Marks and **Samuel I. Stupp** have been elected to the National Academy of Engineering, among the highest professional distinctions accorded to an engineer. The NAE cited Marks (top) for his innovations in electronic, photonic, and photovoltaic materials and catalytic polymerization, while Stupp (bottom) was lauded for advances in processes of self-assembled polymers for biomedical applications.

Marks, the Vladimir N. Ipatieff Professor of Catalytic Chemistry and professor of materials science and engineering, is a world leader in the understanding and development of new catalysts that enable the production of recyclable, environmentally friendly, and sustainably produced plastics and elastomeric materials. His research has resulted in a far deeper understanding of chemical bonds and has directly led to multibillion-dollar industrial processes. Among his many honors are the US National Medal of Science and membership in the American Academy of Arts and Sciences and the National Academy of Sciences. Marks also received the 2012 National Academy of Sciences Award in Chemical Sciences, the academy's highest honor for chemical research.

Stupp, the Board of Trustees Professor of Materials Science and Engineering, Chemistry, and Medicine and director of Northwestern's Institute for Bionanotechnology in Medicine, conducts research focused on molecular self-assembly strategies to create highly functional materials of interest in widely varying fields ranging from regenerative medicine to electronics. He has developed novel materials to promote regeneration in the central nervous system, bone, cartilage, and blood vessels and has used self-assembly to create electronically active materials with a focus on energy technologies. A member of the American Academy of Arts and Sciences, Stupp has received a Department of Energy Prize for Outstanding Achievement in Materials Chemistry and the Materials Research Society Medal. In 2005 *Scientific American* named him one of 50 "Leaders Shaping the Future of Technology."

The NAE elected 66 new members and 10 foreign associates. It acts as the federal government's chief advisory agency on engineering and technology issues. Its more than 2,000 peer-elected members and foreign associates are senior professionals in business, academia, and government.

STUDENTS IMPROVE TREADMILL FOR WHEELCHAIR ATHLETES



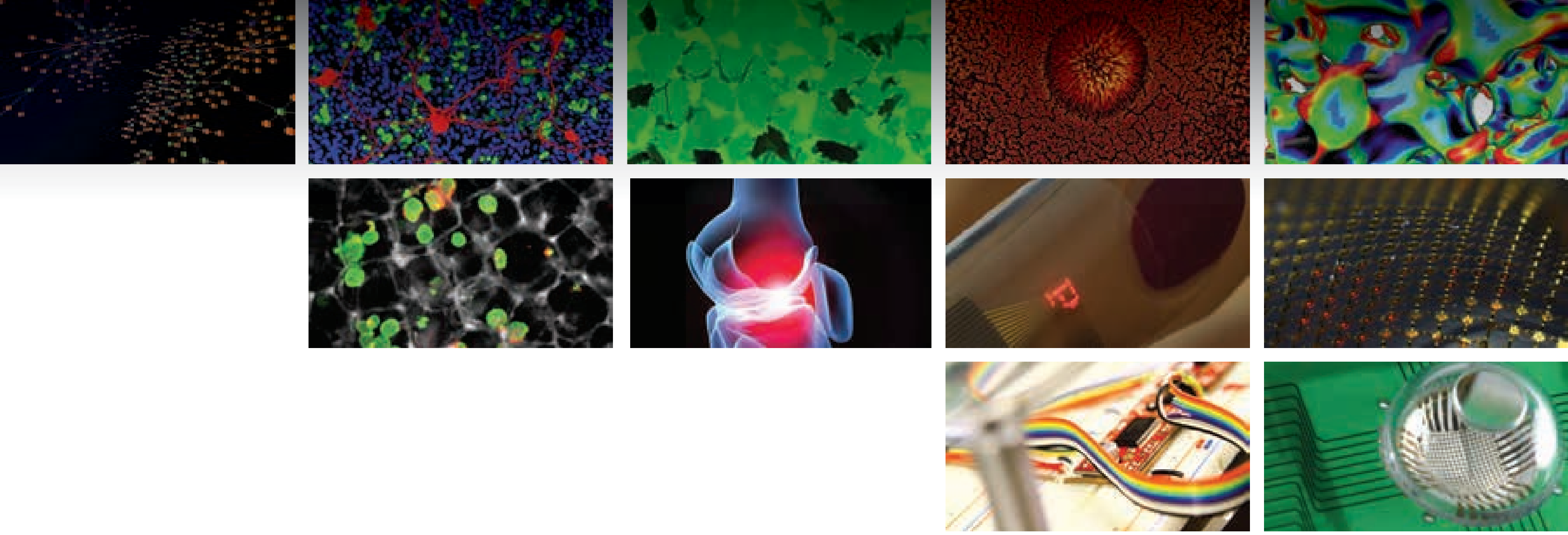
It had been a long week for students in Engineering Design and Communication. As their first quarter at Northwestern came to an end, students in the freshman design course had completed what may have been their grandest collegiate accomplishment to date: a prototype for a piece of computerized workout equipment for wheelchair athletes.

Engineering Design and Communication is a two-quarter course required of new McCormick undergraduates. In the first quarter, EDC students create projects to help physically disabled people at client organizations such as the Rehabilitation Institute of Chicago and Children's Memorial Hospital. Last fall, one section of the class focused on an exercise device called a trainer that accommodates various shapes of racing and sporting wheelchairs and simulates wind resistance for athletes at the Rehabilitation Institute of Chicago's Fitness Center and Sports Program.

The students started by interviewing athletes and staff at the Rehabilitation Institute to learn about the shortcomings of its current equipment. They learned athletes were not able to get onto the trainer by themselves; two staff members were required to lift them. Furthermore, the trainer provided only one level of resistance and accommodated only one type of athletic wheelchair, preventing many athletes from using the machine. "We asked the EDC class to tackle all these shortcomings and create a piece of exercise equipment that could be utilized much like a treadmill, only for wheelchair users," said Eric Johnson, program specialist at the institute.

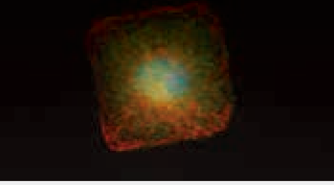
The result was the "Lone Roller." The prototype addressed these concerns and added a system to lock wheelchairs, as well as a computerized control system that allows athletes to vary the level of their workouts and to get data readouts of their performance. The device will help the institute address basic exercise needs and aid in athlete training and performance testing, and it may be used in research projects, as well, Johnson said. "We couldn't be more thrilled to have this piece of equipment as a staple for our sports and fitness programs."

Completing the project in such a short time is an achievement, said **Aaron Stebner**, an EDC course instructor and PhD student with years of industry experience. (See page 34 for a profile of Stebner.) In a commercial market, he explained, the trainer prototype would be assigned to a large team of experienced engineers, professional assemblers, and wirers, and it would still take 20 to 25 weeks to complete the job. "It is absolutely remarkable that a class of 15 first-quarter engineering students researched, designed, manufactured, programmed, and built a fully functioning product for their client in 10 weeks," he said.

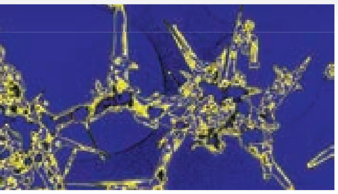


the great intersection™

In a world of accelerating transformation, boundaries between science, engineering, technology, and medicine are blurring. Under these dynamic conditions, we face global challenges of a scale never before seen. Engineering plays a critical role in addressing our challenges. That's why we are building the Robert R. McCormick School of Engineering and Applied Science at **The Great Intersection:** the intersection of global challenges and the knowledge required to solve them.







This intersection

provides a framework through which to view the world, and we are making strategic investments in research areas that will drive our progress in the coming years. These areas themselves intersect, involving faculty members throughout the school.

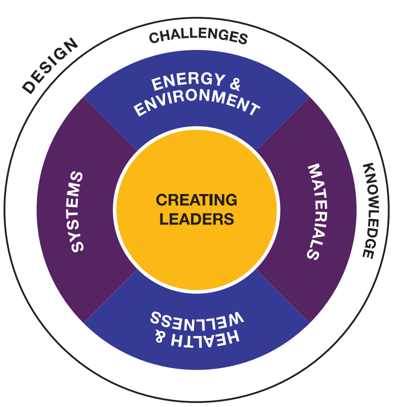
We are focusing on two areas of core knowledge: **systems** and **materials.** Research into systems seeks to understand the many interactions that shape our world and to use that knowledge to build new, effective solutions. The study of materials provides the substance for many solutions, and advances in materials science unlock avenues that were previously unimaginable.

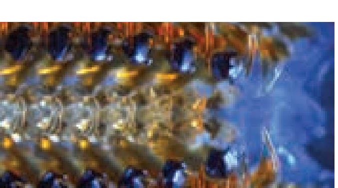
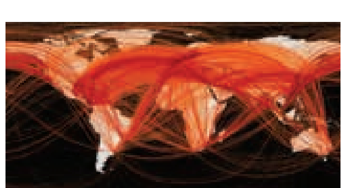
These areas of knowledge intersect with two of the greatest global challenges: **energy and environment** and **health and wellness.** As traditional energy sources diminish, we live in a time when tackling energy and environmental problems requires both finding new sources of energy and increasing the efficiency of our current sources, all while understanding and minimizing their effect on our environment.

Another grand challenge is ensuring the health and wellness of all people. The problems we face are broad and complex, requiring new ways of thinking about health care, technology, and processes. In both areas of challenge, multidisciplinary teams of researchers combine complementary specialties and thinking to study problems at all levels, from molecular changes to complex systems.

At the core of our efforts is a commitment to **creating leaders** who thrive at The Great Intersection. We educate engineers who have superior technical abilities combined with divergent, creative thinking skills: whole-brain entrepreneurs, designers, communicators, and, ultimately, leaders in industry, academia, and beyond who thrive at this intersection. Underlying our efforts is design, which permeates our curriculum and offers a way to frame ideas.

The following pages showcase representative projects in each of our strategic areas.



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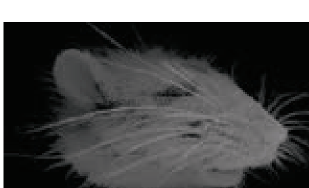
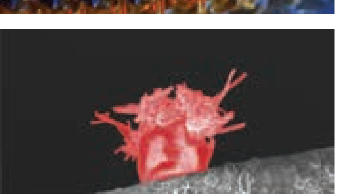
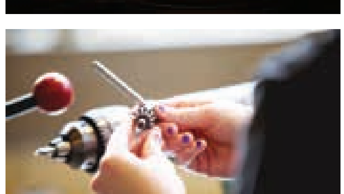
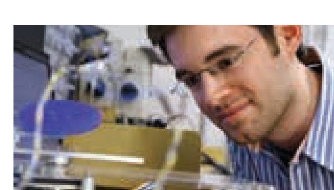
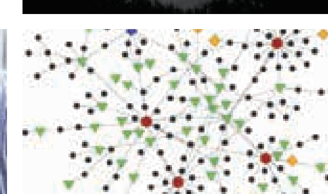
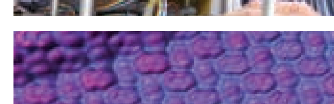
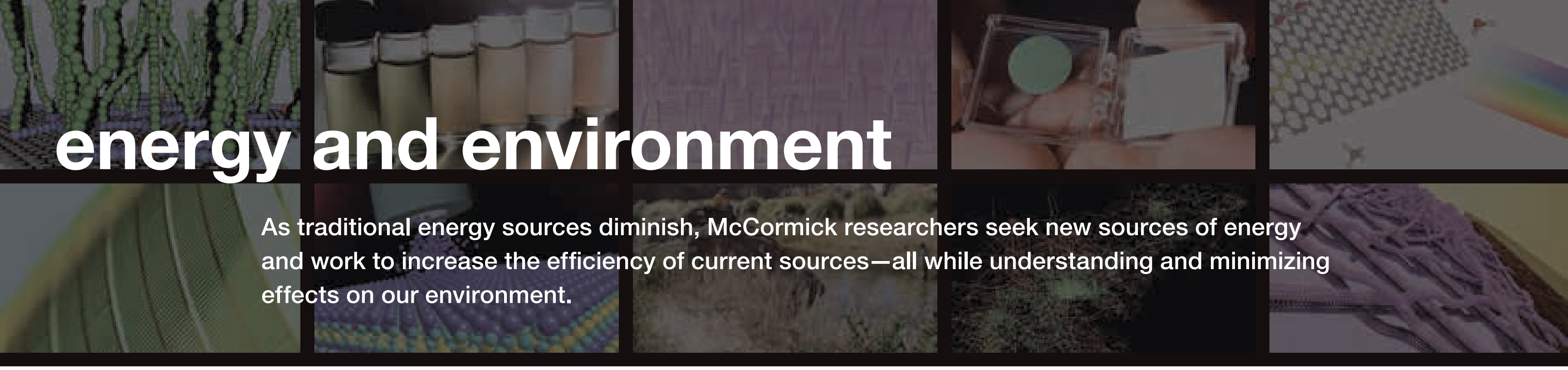








energy and environment

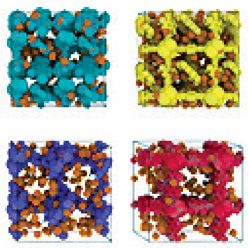
As traditional energy sources diminish, McCormick researchers seek new sources of energy and work to increase the efficiency of current sources—all while understanding and minimizing effects on our environment.

Zeroing in on natural gas storage

There are 13 million vehicles on the road today that run on natural gas—including many buses in the United States. Thanks to recent discoveries of natural gas reserves, this number is expected to increase sharply. Yet storing natural gas remains a challenge. Researchers know that porous crystals called metal-organic frameworks, with their nanoscopic pores and incredibly high surface areas, are excellent materials for natural gas storage. But with millions of different possible structures, how do we know which one is best?

Until recently the process for answering that question meant painstakingly creating and testing each material in a lab. Now, thanks to a new algorithm created in the lab of Randall Q. Snurr, professor of chemical and biological engineering, researchers can generate and test hypothetical metal-organic frameworks (MOFs) to rapidly zero in on the most promising structures. Using a library of 102 chemical building-block components, the researchers generated more than 137,000 hypothetical MOF structures—a number much larger than the total number of MOFs (approximately 10,000) reported to date by all researchers—and tested them computationally for their ability to store natural gas.

"Our team then synthesized one of the most promising materials and found that it beat the US Department of Energy's natural gas storage target by 10 percent," Snurr says. "This is proving to be an exceptionally powerful tool." ■



McCormick researchers have found a way to zero in on the most promising metal-organic frameworks, shown in simulation.

In pursuit of a flexible, affordable solar cell

Imagine a solar-powered tent that could be stuffed into a backpack, or a jacket that could power your iPod. Products like these could never be realized with the stiff, bulky solar cells of today. But soon they could be within reach, thanks to a new solar cell material created by Mark C. Hersam (above right), professor of materials science and engineering, chemistry, and medicine, and Tobin J. Marks, the Vladimir N. Ipatieff Professor of Catalytic Chemistry and professor of materials science and engineering.

Solar cells today are reliant on indium tin oxide, one of the few materials that will allow light to pass into the cell and electricity to pass out. But indium tin oxide has drawbacks: it's brittle, and it's made from an increasingly rare element, indium. That could be a problem if demand for solar cells grows.

Hersam and Marks are looking to single-walled carbon nanotubes—tiny, hollow cylinders of carbon just one nanometer in diameter—as a solution. Carbon is abundant, inexpensive, and flexible—perfect for on-the-go solar technology. "With this mechanically flexible technology, it's much easier to imagine integrating solar technology into everyday life, rather than carrying around a large, inflexible solar cell," Hersam says. ■

Rethinking rechargeable batteries

Reducing our dependence on oil is one of the major challenges of the 21st century. Electric-powered automobiles could be a large part of the solution, but before we can make the leap to these more sustainable vehicles, we have to address their major shortcoming: rechargeable batteries. Today's lithium-ion batteries—the type found in cell phones, iPods, and electric cars—hold too little charge and recharge too slowly to make electric cars an attractive option for most Americans.

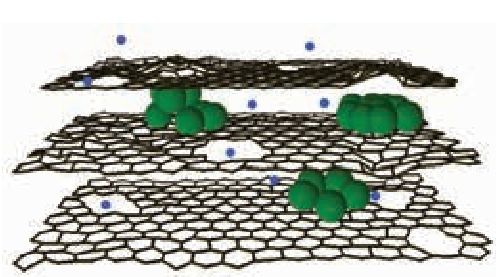
But that could be changing. Harold H. Kung, professor of chemical and biological engineering, is one of several McCormick researchers at work on an advanced lithium-ion battery that could power the devices of the future. By developing new materials for the electrode—the positive (cathode) and negative (anode) ends of the battery where charging occurs—Kung is obtaining dramatic results.

"We have developed a material that can extend the charge life of the anode of a lithium-ion battery by 10 times when it is new," Kung says. "Even after 150 charges, which would be one year or more of operation, it is still five times more effective than the one used in lithium-ion batteries on the market today." In other words, if coupled with a matching positive electrode, Kung's redesigned battery could charge a cell phone in 15 minutes and keep it charged for more than a week.

Charge capacity and rate can be explained by the movement of lithium ions within the batteries as they travel between the anode and the cathode. As the charge is drawn out of the battery, the lithium ions move from the anode to the cathode through a liquid known as the electrolyte; as the battery is recharged, the ions make the reverse trip.

In current batteries only so many lithium ions can be packed into the anode and cathode. Anodes—the focus of Kung's research—are made of layer upon layer of carbon-based graphene sheets, which can accommodate only one lithium ion for every six carbon atoms. This limits the battery's charge capacity and determines how long its charge lasts.

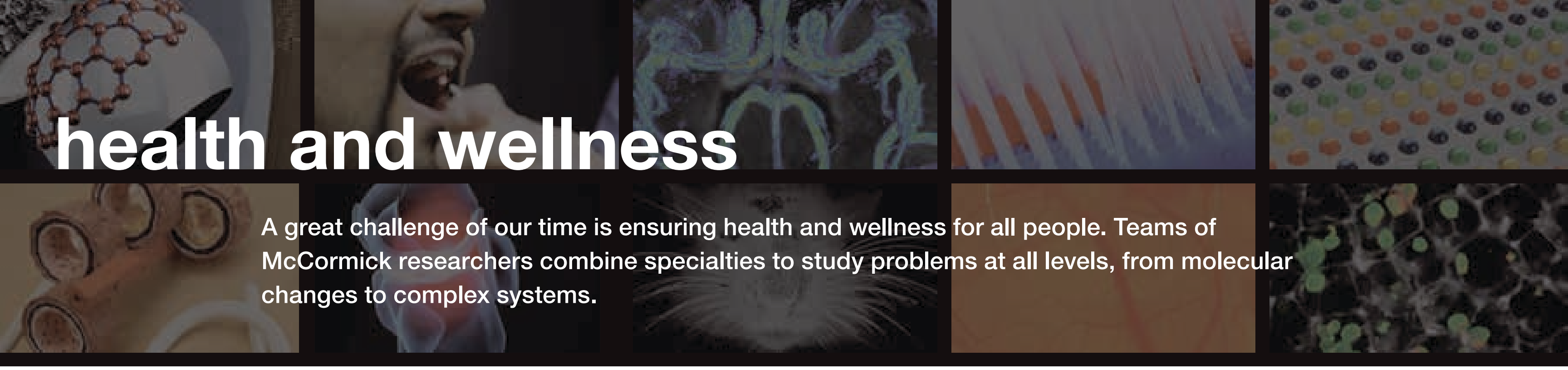
Kung has found a way to fit more lithium ions into the anode. His design utilizes silicon, which can accommodate much more lithium than graphene can—four lithium ions for every silicon atom. There are difficulties with silicon, however: it tends to fracture due to expansion and contraction during charging. To deal with this instability, Kung sandwiches clusters of silicon between the graphene sheets—getting, in his words, "the best of both worlds" by combining the two materials.



A newly designed battery anode utilizes silicon atoms (shown in green) to increase the battery's charge capacity, while "in-plane defects," or tiny holes, allow lithium ions (shown in blue) to reach their destination sooner and charge the battery more quickly.

Kung's team also found a way to speed a battery's charge rate. How quickly a battery can be recharged depends on how quickly the lithium ions travel from the electrolyte into the anode. In current batteries, that process is slow because the graphene sheets, while extremely thin (just one atom thick), are very wide. In the recharging process, lithium ions must travel all the way to the edges of the graphene sheet before coming to rest sandwiched between and in the middle of the sheets. The result is a sort of ionic traffic jam at the edges of the sheets that slows the charging process. Kung's solution, published last fall in the journal *Advanced Energy Materials,* is to bore minuscule holes in the graphene sheets so that the lithium ions can percolate through the thin sheets. The holes—called "in-plane defects"—speed recharging by up to 10 times.

Kung's team will next work on the cathode of lithium-ion batteries. "The cathode is the next crucial step," Kung says. "If we can make improvements there that are cost-effective, we are looking at a quantum improvement in battery performance." If the team is successful, results may be seen in the market within five years, Kung says—first in smaller batteries and eventually in cars. ■



health and wellness

A great challenge of our time is ensuring health and wellness for all people. Teams of McCormick researchers combine specialties to study problems at all levels, from molecular changes to complex systems.

Using light to detect the first shadows of cancer

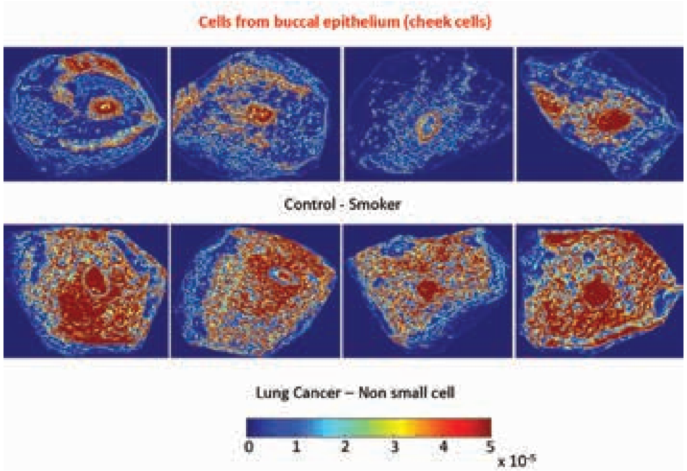
For years it has been the goal of Vadim Backman, professor of biomedical engineering, to see a simple, noninvasive test for the most common cancers become widely available in physicians' offices. In his lab in the basement of Silverman Hall, Backman and his group—in partnership with Hemant K. Roy, director of gastroenterology research at NorthShore University HealthSystem—have tested, optimized, and perfected two biophotonic technologies that rely on what is called the "field effect": a biological phenomenon of the earliest stage of cancer in which cells undergo nanoscale genetic and epigenetic changes across a range of tissues. Now these technologies can detect early changes in small, easily accessible tissue samples—from the cheek for lung cancer and from the base of the rectum for colon cancer. It's an elegant solution that, having done well in clinical trials, could soon become part of a routine checkup.

The first technology uses a technique called low-coherence enhanced backscattering spectroscopy, in which a fiber-optic probe measures how light bounces back from tissue to search for cancer's fingerprint in the nanoarchitecture of its cells. Physicians can use the small probe to test tissue in the base of the rectum for colon cancer or during a standard upper endoscopy for pancreatic cancer, which has been historically extremely difficult to detect in its early stages. After successful clinical trials, the technology has been licensed to a company and could be in use in Europe as early as 2013 and in the United States following FDA approval.

Backman's other technology, nanocytology, also makes use of field effect, but instead of a probe, a physician swabs a small sample from the patient, and researchers use a specialized partial-wave spectroscopy microscope to examine the cellular nanoarchitecture of the sample. The research group under Backman and research associate Hariharan Subramanian has conducted clinical trials using this technique for lung, colon, pancreatic, esophageal, and ovarian cancer—all with cells gathered noninvasively, and all with promising results. "It's truly a platform technology," Backman says.

What might be most interesting about nanocytology is that it detects the same cellular changes in all of these cancers. "These five organs are drastically different," Backman says, "yet this change is the same. What can we learn about cancer's process from this?"

Backman has teamed with Allen Taflove, a professor of electrical engineering and computer science and the Bette and Neison Harris Professor of Teaching Excellence, and Igal Szleifer, the Christina Enroth-Cugell Professor in biomedical engineering, to mathematically model this effect in order to understand the biology behind it. "We had no way to look at these changes before," Backman says. "Now we can combine engineering, physics, micromolecular processes, and biology in an attempt to truly understand cancer." ∎



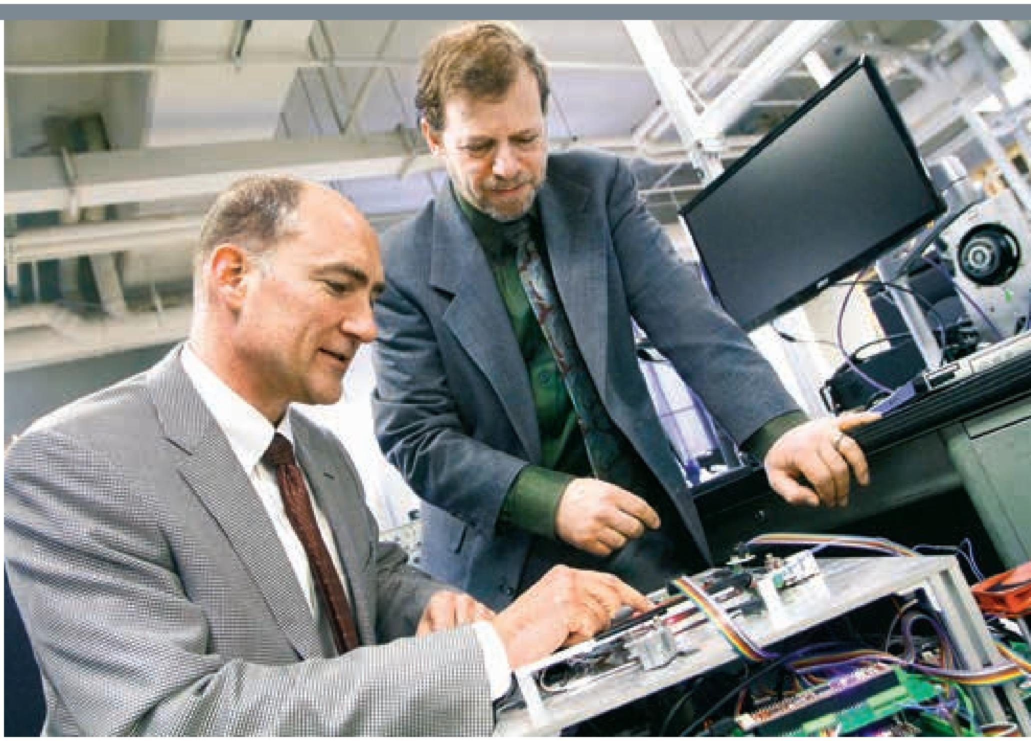
Right: Images of representative buccal epithelial cells from cancer-free patients (top) and patients harboring lung cancer (bottom) taken using partial-wave spectroscopy microscopy, a technique developed by Vadim Backman and his collaborators.
Far right: Vadim Backman, right, and graduate student Dhwanil Damania discuss a specimen.

Rehabilitation robotics

Ed Colgate (left) and Michael Peshkin (right) want robots to work for us—especially when we're most vulnerable. Colgate, the Allen K. and Johnnie Cordell Breed Senior Professor of Design and professor of mechanical engineering, and Peshkin, professor of mechanical engineering, conduct research in human-robot interaction. With close ties to the Rehabilitation Institute of Chicago (RIC), they've developed several robotic devices for rehabilitation, including the KineAssist, which helps stroke patients regain the ability to balance and walk.

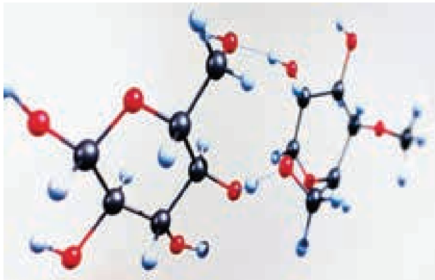
Working with Todd Kuiken, professor of biomedical engineering at McCormick and of physical medicine and rehabilitation at the Feinberg School of Medicine, as well as director of RIC's Neural Engineering Center for Artificial Limbs, they helped develop a new kind of prosthetic arm that works with the amputee's own nerves. They used their research in haptics—tactile feedback technology that uses touch as an interface—to give the arm "touch feedback" capabilities.

"With our strong robotics group and our connections with the Rehabilitation Institute, we really have a rich set of research opportunities that hopefully will result in better prosthetics for everyone," Colgate says. ∎

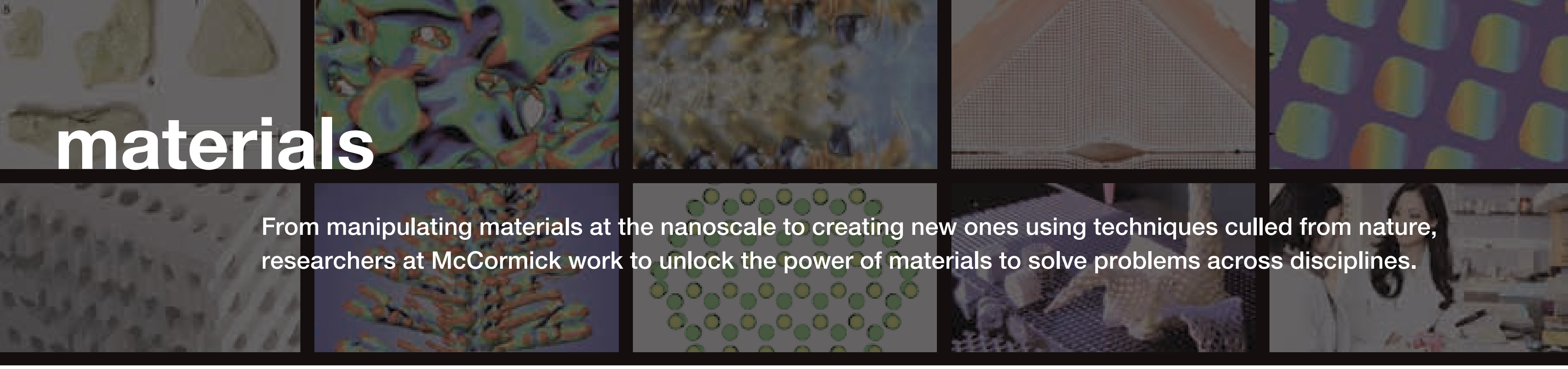


Modeling complex reactions

Linda Broadbelt (right), an expert in the computer generation of complex reaction mechanisms, is known for modeling chemical reactions that have implications for everything from recycling to tropospheric ozone formation. Now Broadbelt, chair and professor of chemical and biological engineering, is making her move in medicine: She is partnering with Keith Tyo, assistant professor of chemical and biological engineering, to develop new biosynthetic processes that use inexpensive materials like sugar to make more affordable drugs for the developing world. She's also working with Lonnie Shea, professor of chemical and biological engineering, to identify active pathways in the cell array technology developed by Shea that could be used to investigate the progression of diseases or to promote the development of functional tissue replacements. "Partnering with other professors allows us to tackle these complex problems from both computational and experimental standpoints," she says. ∎

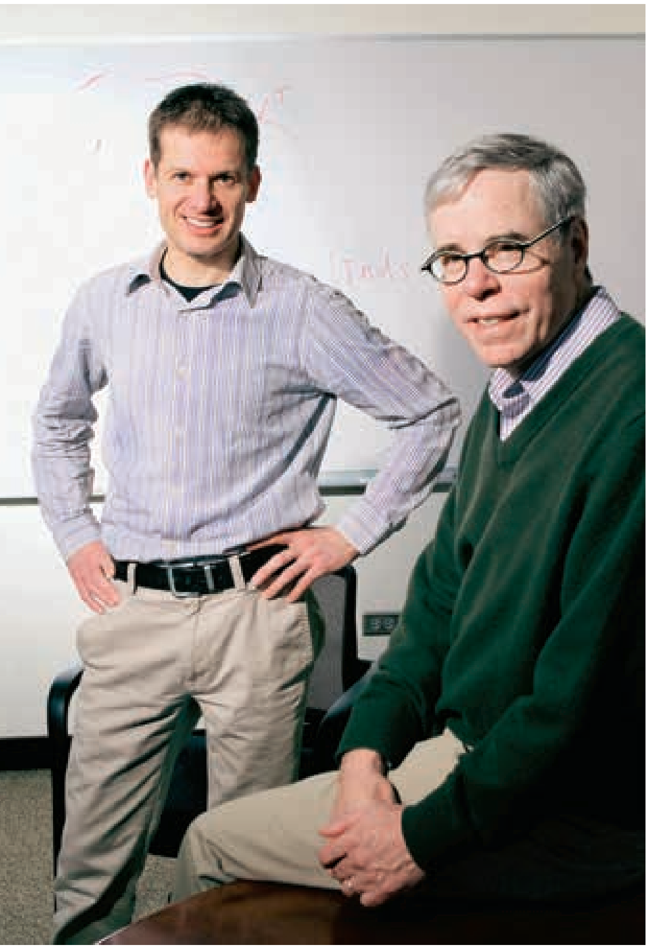


Left: Glycosidic cleavage of methyl-cellobiosan: Using quantum mechanics, the Broadbelt lab has discovered a mechanism for the decomposition of cellulose, the dominant component of plant biomass, which has eluded researchers for more than 90 years. This understanding will advance efforts to produce renewable energy from cellulosic biomass.



materials

From manipulating materials at the nanoscale to creating new ones using techniques culled from nature, researchers at McCormick work to unlock the power of materials to solve problems across disciplines.



Computational materials science opens doors to quicker, cheaper discoveries

It could pass for a video game: a mass of yellow, blue, and green dots that writhe and collide with errant pink flecks. But the scene that plays out on Erik Luijten's computer screen is actually a simulation of an experimental gene-repair therapy, demonstrating on an atomic level how a synthetic polymer molecule could deliver a healthy strand of DNA to a genetically mutated cell.

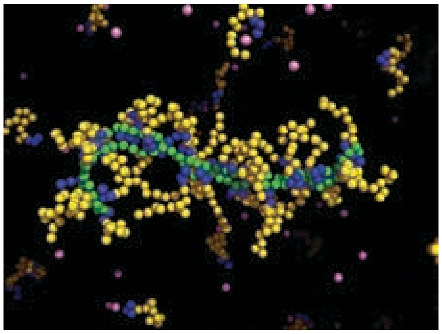
"Something as rudimentary as the shape of the polymer molecule can have a huge impact on how the healthy DNA gets distributed in the body," explains Luijten, associate professor of materials science and engineering and of engineering sciences and applied mathematics. "My job is to figure out how to create those different shapes."

And how does he do that?

"A bit of experience and a bit of magic," he says.

Luijten isn't a biologist—or a magician, for that matter. He's a computational materials scientist—a "simulator," he says, as opposed to the more traditional "experimentalist."

Computational materials science is transforming the way researchers make materials. From skyscrapers to space shuttles, materials science has been responsible for creating the objects that fill our everyday lives. It's a process that generally requires laboratory experiments, but developing



Left: Erik Luijten (left) and Peter Voorhees
Above: Simulation image of a nanoparticle designed for gene therapy purposes. Plasmid DNA (green) is encapsulated by polymers (blue and yellow) to protect it during transport and to facilitate its entry into a cell.

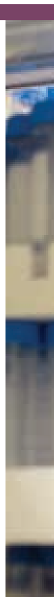
Researchers find promise in "crumpled" graphene

They're the building blocks of graphite: ultrathin sheets of carbon, just one atom thick, whose discovery was lauded in 2010 with a Nobel Prize in physics. Graphene, many researchers believe, could impact everything from electronic devices to high-performance composite materials. It is extremely strong and an excellent conductor, and, with no internal structure at all, it offers an abundance of surface area—much like a sheet of paper.

Until recently, however, working with graphene has been difficult. Like a deck of cards, graphene sheets easily stack into piles, reducing their surface area and making them unprocessable. But researchers at McCormick have now developed a new form of graphene that doesn't stack. It is made by crumpling the graphene sheets into balls.

"If you imagine a trash can filled with paper balls, you really get the idea," says Jiaxing Huang, the Morris E. Fine Junior Professor in Materials and Manufacturing (far right). "The balls can stack up into a tight structure. You can crumple them as hard as you want, but their surface area won't be eliminated."

The crumpled shape is created by moistening the graphene sheets and placing them in a furnace to evaporate the moisture, says Huang, who adds that their potential is great: "We expect this to serve as a new graphene platform for numerous applications, such as energy storage and energy conversion." ■



new materials experimentally can be painstakingly slow, particularly in highly regulated industries. Certifying new materials for aerospace applications, for example, can take more than a decade as researchers stage experiments time and time again.

"It's expensive, it's laborious, it's time consuming, and then you make the material and find out it doesn't work," Luijten says. "Was your intuition wrong? Was the experiment contaminated? In a computer, on the other hand, everything is perfectly controlled."

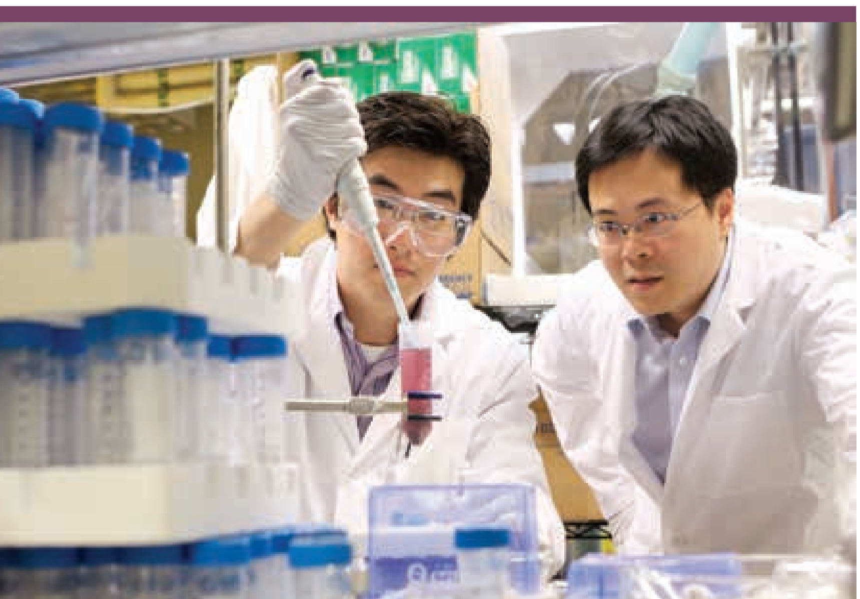
By manipulating millions of pieces of data describing the charge, size, and other characteristics of particles, Luijten and his peers are able to predict how materials will behave in the presence of other materials or under certain environmental conditions such as heat or strain.

The process can also be flipped on its head, says Peter Voorhees, the Frank C. Engelhart Professor of Materials Science and Engineering and professor of engineering sciences and applied mathematics. "We can now say, 'What kind of properties are you looking for in a material?' and then go back to the periodic table, pick A, B, and C, and make it on the computer," he says.

Voorhees uses computational materials science to predict the structure of materials composed of more than one phase. Using computer codes, Voorhees can determine exactly how to process combinations of metals, such as aluminum and copper, to make them as strong as possible—vital information for metal makers, airplane manufacturers, and other industries. The same process allowed Chris Wolverton, professor of materials science and engineering, to help design an ultralight aluminum engine block for the Ford Motor Company, and Greg Olson, Walter P. Murphy Professor of Materials Science and Engineering, to design a high-performance gear steel commercialized through his company, QuesTek Innovations.

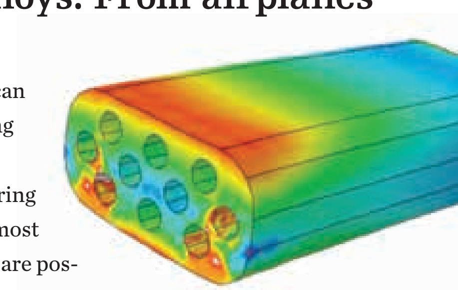
Computational materials science can't replace lab experiments, Voorhees says, but the two can work together to greatly shorten the development process. "The idea is to make the design process two cycles instead of ten," he says.

While it's still early, Luijten says the field holds enormous promise for everything from the automotive industry to biomedical engineering to energy harvesting. "We are just at the start of this process," Luijten says. "We are really thinking outside the box." ∎



Left: Cate Brinson
Below: A shape memory alloy, MicrochanBeam, containing microchannels that minimize the weight of the actuation component and help achieve the best possible fuel efficiency in aircraft
Bottom: An X-ray tomography image of a porous shape memory alloy foam. The material may be used in bone and joint implants and aerospace

Shape memory alloys: From airplanes to implants

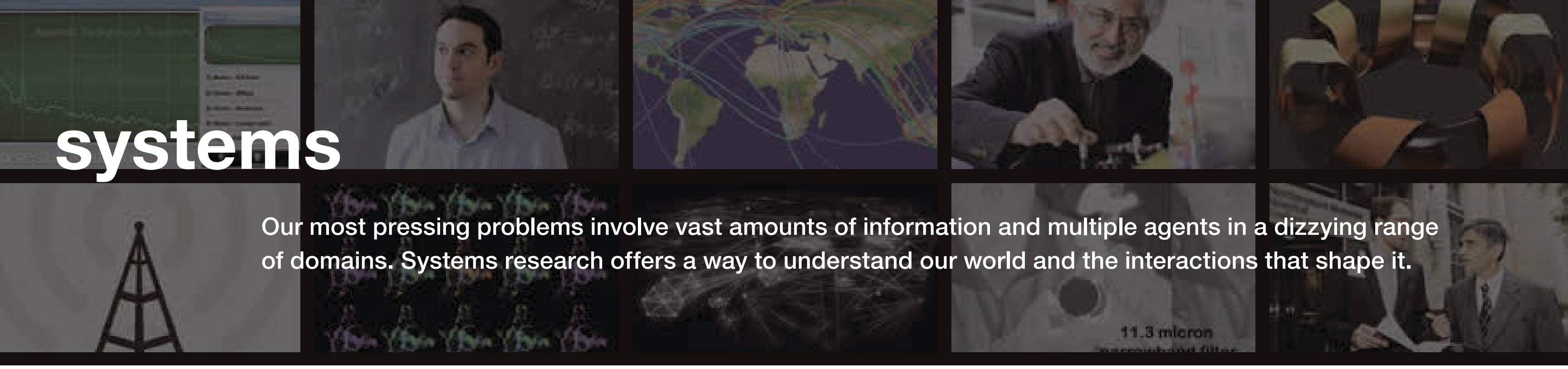


Picture an airplane engine that can change shape during flight, taking the optimal form for a smooth, quiet takeoff and then reconfiguring itself at cruising altitudes to its most fuel-efficient shape. Such things are possible with shape memory alloys, a type of metal that can "remember" its original shape and revert to it under a stimulus such as heat or electric current.

Shape memory alloys can set a device in motion without the added bulk and noise of a motor—an asset in aerospace applications, where each extra gram means added fuel cost. And they're already being used for some medical purposes, such as stents: unlike a stainless steel stent that must be implanted using balloon inflation, a shape memory alloy stent can self-deploy as it warms inside the body.

Now McCormick researchers are looking at adding something new to shape memory alloys: pores. "One idea is to use this new material in bone and joint implants," says Cate Brinson, the Jerome B. Cohen Professor in mechanical engineering, who, along with David Dunand, the James N. and Margie M. Krebs Professor in materials science and engineering, is exploring the new material. "Porous shape memory alloys have a lower stiffness, like real bone, reducing atrophy of the surrounding bone tissue and allowing the bone to grow into the pores for stabilization."

The porous material could also find its way into aerospace in the form of lighter, shape-shifting engines and other lightweight actuation applications. "When you couple this lighter, more flexible material with shape memory alloys' ability to change shape, there is a multitude of possibilities," Brinson says. ∎



systems

Our most pressing problems involve vast amounts of information and multiple agents in a dizzying range of domains. Systems research offers a way to understand our world and the interactions that shape it.

Rewiring nature's building blocks to solve global challenges

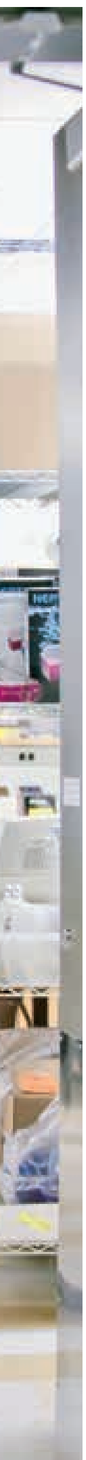
The goals are lofty: develop low-cost energy solutions, design new ways to fight cancer, and create advanced materials. Armed with a new approach to engineering biological systems, a growing cohort of early-career chemical and biological engineering professors at McCormick is using synthetic biology as a way to solve global challenges and inspire a new generation of engineers.

"We've each come to synthetic biology as an approach that enables us to take on big problems in new ways," says Josh Leonard, assistant professor. "We each bring unique capabilities, and as our numbers grow, we're building new collaborations and a new synergy here at Northwestern."

Synthetic biology is a broad term for the design and construction of new types of biological systems that can be used in health care, energy, technology, and materials. For example, Leonard is developing cell-based devices that can be programmed to create customized therapeutics. In one project he engineers protein-based sensors to detect molecules produced by tumors; he then engineers cells to use these sensors to locate tumors and produce proteins that activate the body's immune defense system against them. In related projects he is developing "smart" vaccines, treatments for chronic autoimmune diseases, and bacteria-based therapeutics.

Michael Jewett, assistant professor, takes a different approach. He uses cell-free systems (which activate complex biological processes without using intact, living cells) to achieve an unencumbered platform for activating, controlling, and modifying the infrastructure of biology. The work being done by Jewett—who has received the Young Faculty Award from DARPA, the Agilent Career Early Professor Award, and a Packard Foundation fellowship—could play a role in making lifesaving therapeutics, sustainable chemicals, and novel materials, both quickly and on demand.

Jewett and Leonard were joined last year by Keith Tyo, assistant professor, who studies cells' metabolic networks to synthesize new materials (drugs, therapeutics, and fuels from cheap and renewable materials) and engineer new kinds of sensors (such as cell-based diagnostic devices for the developing world). Tyo recently received a synthetic biology grant from the Bill and Melinda Gates Foundation. He is also involved in a project with the Chicago Biomedical Consortium, working with neuroscientists and biologists at the University of Chicago and the Rehabilitation Institute of Chicago to develop novel methods to measure how and when brain neurons fire.



Using analytics to deploy car charging stations

After a few starts and stops, electric cars finally seem to be catching on: projections show that by 2015, a million electric vehicles will be on US roads. But drivers of electric vehicles often have a limited choice of charging stations, and as a result they experience what is called "range anxiety" when they get close to current batteries' 100-mile limit. Finding the right spots to place charging stations is key to wider use of electric cars.

Diego Klabjan, associate professor of industrial engineering and management sciences, is using innovative analytical methodologies to solve this problem. Working with the Chicago Area Clean Cities Coalition and other partners, he looks at several factors to determine charging locations, including where and how people drive, where potential electric vehicle drivers might live, and where these drivers might want to spend their time while their cars charge. Klabjan analyzes the data using discrete-choice modeling to chart demand, create optimization techniques to find the best locations, and run simulations to assess system performance. Eventually his results will drive a web-based decision support software application so users can choose locations based on investment budget, electrical power-grid, geographic, and infrastructure constraints.

"My goal is to see this type of decision making adopted across the United States," he says. "It's data driven and will save a substantial amount of time deploying charging stations."

Last winter assistant professor Neda Bagheri joined Jewett, Tyo, and Leonard (shown, from left). Bagheri uses control theory to understand complex regulatory networks governing cancer development, immune function, and circadian biology. Now, these faculty members are pushing each other to consider how their separate research areas can complement one other and spur on further discoveries.

In addition to pursuing research, the group aims to inspire a new generation of synthetic biologists. Members advise undergraduate teams in the International Genetically Engineered Machine competition, in which students are given a kit of biological parts and charged with building synthetic biology systems. This year's team developed an *E. coli* biosensor to detect the presence of pathogens in hospitals and on medical equipment. Its project earned the Best Model Award at the Americas' regional competition, allowing the team to advance to the world championships. (See story on page 3.)

"We get to work with undergraduate students and be part of their discovery process," Jewett says. "The ideas are theirs, the project is theirs, and we get to help them choose good problems."

These four young McCormick faculty members have growing reputations: they have won key fellowships, hosted conferences, and testified before Congress, and more and more graduate students are coming to the department to study synthetic biology with them. "The environment here at McCormick allows us to bring the right pieces together—not only to see what people do well but also to seek new connections along new interfaces," Jewett says. "That really breaks down barriers and affords new opportunities for serving society in revolutionary ways."

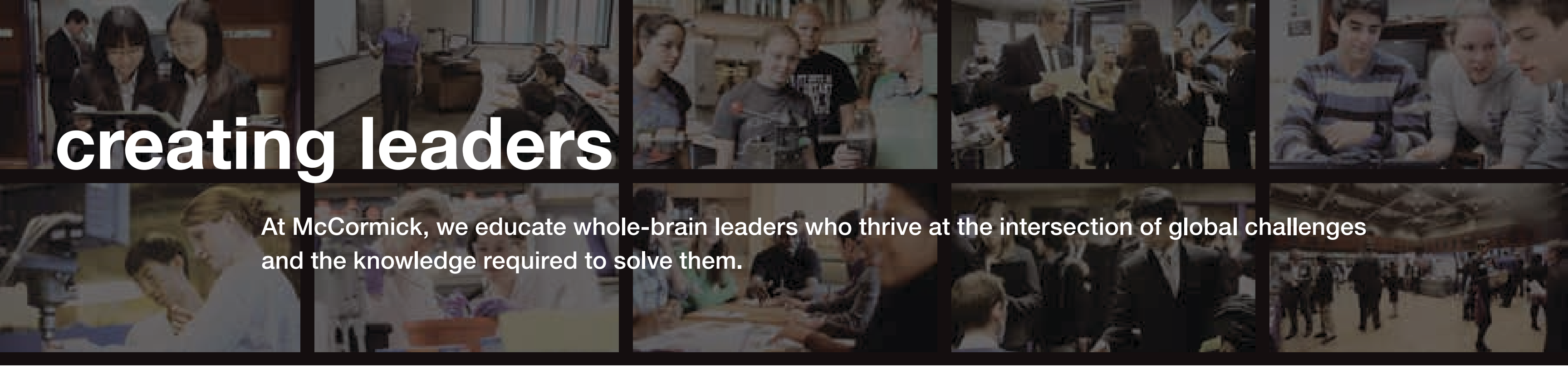
Teaching computers to think like humans

Artificially intelligent computing isn't as foreboding as some science fiction would have it. In fact, as Kenneth Forbus sees it, intelligent computers won't be our enemies at all. "They'll be like dogs," he says. "They'll love us."

For Forbus, the Walter P. Murphy Professor of Electrical Engineering and Computer Science, now is a great time to be a computer scientist interested in artificial intelligence. As computing power increases radically, Forbus is at the leading edge of creating software that thinks like humans.

Forbus is armed with a secret weapon: his collaborator (and wife), Dedre Gentner, the Alice Gabrielle Twight Professor in Northwestern's psychology department. Their partnership has led to cognitive simulations of analogical reasoning and learning that explain aspects of human cognition, including high-level vision, problem solving, and conceptual change. Their collaboration has enabled Forbus to create the educational software CogSketch, which understands and gives feedback based on students' sketches. Forbus is also building a new model of minds called Companion Cognitive Systems. Companions are intended to act as collaborators, helping their human users work through complex arguments by gathering new information and adapting to and learning about their environment and users.

"Modeling how people think computationally is tremendously fun," Forbus says.



creating leaders

At McCormick, we educate whole-brain leaders who thrive at the intersection of global challenges and the knowledge required to solve them.

Overcoming the greatest challenges of our time requires more than knowledge. It requires creativity, daring, the ability to bring people together, and, yes, the willingness to fail. The engineers of tomorrow must be more than experts in their fields; they must be great leaders. With this in mind, McCormick is dedicated to providing academic, career-oriented, and extracurricular opportunities to empower the leaders of this generation.

Preparing for the future

For Brian Chester (chemical engineering ’13), opportunity means packing up his textbooks and breaking out his button-downs. This spring, instead of attending his regular classes, Chester headed to Midland, Michigan, to help develop new monitoring systems for the Dow Chemical Company. He is taking part in the Walter P. Murphy Cooperative Engineering Education Program (co-op), which allows students to alternate periods of academic study with full-time periods of paid work experience related to their academic and professional goals.

By the time he graduates, Chester plans to complete at least three stints at Dow in areas such as research and development, manufacturing, and long-term development. “I’m exploring and seeing what’s out there,” Chester says. “And I’m learning a ton about what chemical engineers actually do.”

The Office of Career Development worked with more than 800 McCormick students last year through co-op, internships, and other programs, says Helen Oloroso, assistant dean and director of the Office of Career Development, which provides career advice and integrated learning opportunities. That’s up from just 300 a decade ago.

“Students need more than a good transcript to be competitive in today’s workforce,” Oloroso says. “Potential employers want industry experience—someone who has both the technical knowledge and experience applying it. We prepare our students for that reality.”

Experiences in the classroom and on the job put students on track for success, but true leadership requires life experience, curiosity, and the willingness to move outside one’s comfort zone. McCormick’s Office of Personal Development promotes well-roundedness by encouraging students to explore their strengths, engage in new experiences, and take responsibility for their learning.

The only formally established office of its kind at an engineering school in the United States, the Office of Personal Development hosts its own guest speakers, workshops, and off-campus outings while also promoting events offered throughout the University. “Excellent, transformative experiences take place on this campus all the time,” says Joe Holtgreive, assistant dean and director of the office. “We want to make sure our students take advantage of these opportunities.”

Innovation by design

Whether the result is a space shuttle or a shampoo bottle, design is a vital part of every engineering feat—and a vital part of a McCormick education. At the Segal Design Institute, students learn how good design can shape the environment to satisfy both individual and societal needs. The institute, founded in 2007 with support from Crate & Barrel founders Gordon and Carole Browe Segal, offers courses, projects, certificates, and degrees for undergraduate and graduate students.

The Segal Design Institute is also home to Engineering Design and Communication, a required freshman course sequence in which student teams work with real clients to design products to solve a problem. For most students, it is their initial attempt at product development, and the process can seem overwhelming.

"At first, it felt like we were in over our heads," said Vinithra Rajagopalan (biomedical engineering '15), whose team designed a computerized treadmill to help wheelchair athletes train for races (see related story on page 7). "But now that we're nearing the end, it's just exciting. It feels like we're actually making a difference."

Some designs are so innovative that they can be expanded into businesses. For students interested in creating their own start-up companies to market their products, the Farley Center for Entrepreneurship and Innovation provides an invaluable resource. Founded in 2007 with a grant from the James N. and Nancy J. Farley Foundation, the center offers a series of courses and programs that give undergraduate and graduate students the skills they need to realize their own business plans. Among Farley's offerings are the popular NUvention courses, which take students from across Northwestern through the process of developing products and launching business plans for medical, online, and energy applications.

The Farley experience was nothing short of life-changing for Nikhil Sethi (electrical engineering '10). He and fellow McCormick student Garrett Ullom founded their start-up company, Adaptly, in a NUvention course that exposed students to the product and business development cycle of a software company. Adaptly provides a platform for businesses to buy ads on multiple social networks simultaneously. It now employs dozens of people at its Manhattan location and recently opened an office in London. The company projected 2011 revenues of more than $10 million, and Sethi was named one of *Forbes* magazine's "All-Star Student Entrepreneurs."

Left: Students meet recruiters at a career fair at Norris University Center.
Above: Adam Goodman, director of the Center for Leadership
Above right: Engineering Design and Communication students in action

Creating leaders

From its new home at McCormick, Northwestern's Center for Leadership provides students from across the University with skills to become leaders in their chosen fields. Founded in 1990 as the Undergraduate Leadership Program, the center has provided a popular undergraduate certificate program in leadership to more than 2,500 students over two decades. Recently the center began offering a competitive Leadership Fellowship for advanced PhD students and high-potential Northwestern staff members.

Physically housed at 1813 Hinman Avenue, the center found its academic home at McCormick in 2010. "McCormick students will be called upon to be leaders in their careers, and so it's important for the school to introduce them to the concepts of effective leadership throughout their education," says Adam Goodman, the center's director.

Together with McCormick's Office of Personal Development, the center enables McCormick students to reach their greatest potential and prepares them to become the leaders of tomorrow, says Dean Julio M. Ottino: "With resources like these, McCormick educates whole-brained engineers who thrive at the great intersection. We are only as good as the people we produce. Our value resides in the graduates of our school."

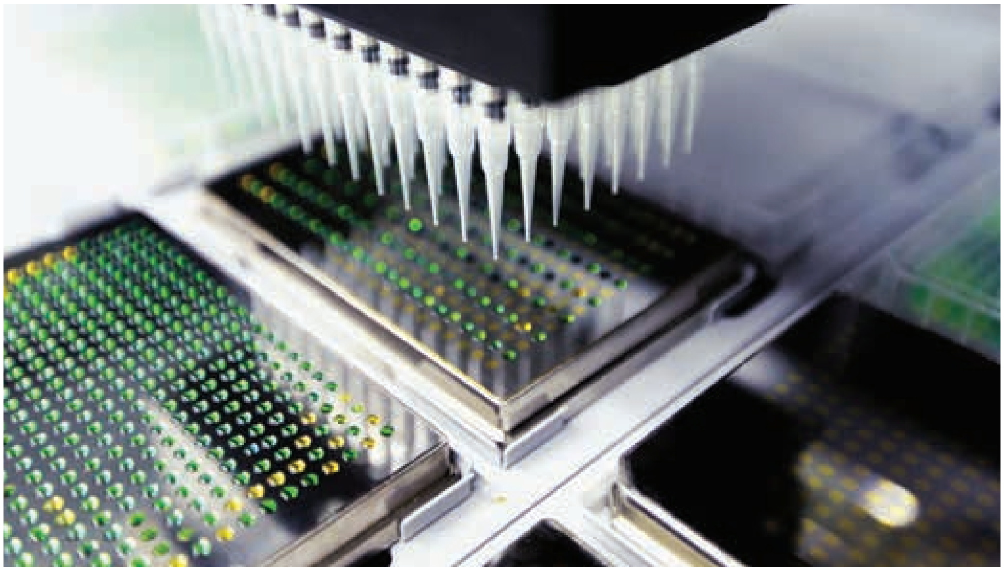
ENGINEERING BIOLOGY

MILAN MRKSICH ENGINEERS NEW WAYS TO UNDERSTAND—AND BUILD ON—BIOCHEMICAL REACTIONS

In a lab on the second floor of the Technological Institute, a robotic arm whirs behind glass, picking up pipette tips and dropping their contents onto a metal surface. But this is not just any surface: No bigger than a postcard, the plate is dotted with hundreds of tiny circles made of the thinnest layer of gold—the perfect surface for testing particular biological reactions. Upon these dots, in tiny droplets of liquid, proteins mix with one another in ways that science has yet to comprehend fully, spurring reactions identical to those that occur inside human cells. “It’s been a three-year process to learn to do all this,” says Milan Mrksich, standing in his newly transplanted lab. “It’s gotten to the point now where it’s ready for prime time.”

Just a few months ago these robots were humming at the opposite edge of the city, at the University of Chicago, where Mrksich held a professorship for 15 years. Last September Mrksich brought his lab to Northwestern, where he holds joint appointments in McCormick, the Judd A. and Marjorie Weinberg College of Arts and Sciences, and the Feinberg School of Medicine in biomedical engineering, chemistry, and cellular and molecular biology. “Those departments all have strengths in the areas we are active in, and Northwestern offers us a broader community that will allow us to take our science further,” Mrksich says. “After my first three months on campus, it was clear to me that I had made the right decision.”

Mrksich is perhaps the world’s leading engineer of the interfaces between materials and biological environments, a research area that blurs the line between the physical and biological sciences. “When we look at a cell, we don’t just see biology,” he explains. “We see the opportunity for using the cells in the physical sciences.” Throughout Mrksich’s career, that research has translated into the pursuit of “hybrid devices,”



A robot delivers droplets of liquid to reaction sites on a special gold-plated surface in the Mrksich group's laboratory.

man-made machines made partly of living cells (such as instruments that use beating heart cells as a power source), and the development of materials that mimic the structural matrix that organizes cells in tissue.

But on this wintry afternoon, watching the robotic arm zip back and forth in its glass housing, Mrksich is focused on a relatively new research area: a process he's named self-assembled monolayers desorption ionization (SAMDI) mass spectrometry, a super-fast, low-cost, and "label-free" method of measuring biochemical activities on a surface—in today's case, reactions between various proteins, peptides, and carbohydrates. While reactions performed in a solution can be easily characterized in minutes or hours, those performed on a surface, while less expensive, could take weeks to characterize—until now.

For Mrksich, studying the interactions between cells and their parts boils down to one overarching idea: living organisms are far better designed than any feat of human engineering, and it is only by truly understanding biology that we can begin to match its efficiency. "Our interest is in the engineering principles of biology," he explains. "When we learn how biological networks operate, not only can we pursue more effective interventions in medicine, but we also can build nonbiological systems that operate by biology's rules and that, unlike man-made systems, display the tantalizing properties of biological systems."

He has his work cut out for him. Despite incredible scientific advances, Mrksich says, researchers remain relatively ignorant about how biological systems actually work. While we have made great strides in understanding individual parts—we know the parts of a cell, for instance, and we can sequence the DNA of whole genomes in a single day—we don't know how these parts work together. "Take a cell," Mrksich says. "We know, in principle, it's not that complicated: It's half the width of a hair, it's got about 3 billion base pairs of DNA, maybe 50,000 proteins. But we still don't understand how these parts interact with each other to make a cell alive, to make it carry out its functions."

To understand the cell, it's vital to understand proteins, Mrksich explains. Proteins are the functional units, or the "doers," in a cell; they catalyze reactions, transmit signals between cells, and their actions can even be linked to various cancers. But when it comes to specifics, things get fuzzy. Of 50,000 proteins, we understand the functions of fewer than half. "That's really quite remarkable. After many years of research by thousands of research groups, we still don't understand what roles these proteins play in biology," Mrksich says. "It's like flying an airplane and not knowing what half the switches control or why they're there."

That's largely because we haven't had the right tools, Mrksich says. Traditionally, discovering protein function has been a slow, tedious process of trial and error. Since it's impossible to see proteins directly, researchers use labels—chemical additives that will leave their mark in a reaction, such as radioactivity or antibodies—to determine whether a protein is active in a reaction. But labels are inherently limiting; they can only test to see whether a specific reaction is occurring, which means researchers have to know what they're looking for in order to find it.

Mrksich has developed another way, which hinges on those gold-plated surfaces. In SAMDI mass spectrometry, each dot—as many as 6,000 per plate, each with its own "address"—is the site for its own reaction. Proteins are tethered to each spot with a sulfur molecule, which has an affinity for gold, and a particular solution is delivered to each site. After the reaction is complete, the plate is put into a vacuum and each dot is struck with a laser that releases the molecules from the gold base. The robot then weighs the contents of each site, allowing researchers to make an educated assumption about what occurred in each reaction.

The result is a highly streamlined, relatively inexpensive process that delivers an enormous amount of data. "Half a dozen years ago, doing 100 experiments in a day would have been considered a good day," says Mrksich. "We do 100,000 experiments in a day. In 18 months we'll be capable of running half a million in a day." Mrksich estimates that each reaction in SAMDI mass spectrometry costs just pennies, compared with about $10 in a standard laboratory.

Mrksich's research is already finding its way into industry. Last summer he founded a company, SAMDI Tech, to commercialize the process for the pharmaceutical industry. The process is especially well suited to the drug discovery process, which currently is extraordinarily lengthy.

"You have a freezer full of different compounds in a lab. In a pharmaceutical company the number is a few million," Mrksich says. "You have one enzyme, and one by one you test small molecules to find those few that block the enzyme function. Instead of trying 10 combinations in a day, imagine trying 1,000—maybe 100,000. Imagine the discoveries we will make." M

Sarah Ostman

Watch a video about Mrksich's research at www.mccormick.northwestern.edu/magazine.

Outreach 101

McCormick students take science to Chicago-area schools

Growing up in a rural community three hours outside Seattle, Travis Johnson didn't have the benefit of a well-funded high school science program. But he did have the benefit of an excellent science teacher. "Joyce Stark," recalls Johnson, a third-year PhD student in applied mathematics at McCormick. "She really went above and beyond the call of duty, running a regional science fair that sent someone to internationals every year. It really set my life in a positive direction."

Today, Johnson, the vice president of the McCormick chapter of the Institute of Electrical and Electronics Engineers, is passing on his love for science to a new generation of students. Johnson and his fellow IEEE members have performed demonstrations in several Chicago-area schools, showing students how to make "oobleck," a non-Newtonian fluid made of cornstarch and water, and how to contact people thousands of miles away using a small tabletop radio and antenna. "The kids love it," says Johnson. "It's fun to see them excited about science."

Johnson is one of many McCormick students who, through student groups, spend time in Chicago-area public schools doing volunteer work and class projects. By offering demonstrations at science fairs, organizing after-school activities, and mentoring up-and-coming young engineers, they are becoming the positive role models for the next generation of scientists and engineers.

STARTING EARLY

The task seemed simple: create an injection-molded plastic toy—a helicopter or action figure, perhaps—that could fit in the palm of a hand. But there was a catch. The toy had to be made to the liking of an unusual set of clients: a class of fourth graders at Nettelhorst Elementary School in Chicago's Lakeview neighborhood.

While short in stature, these clients were tall in demands—a fact that became clear during the first Northwestern-Nettelhorst brainstorming session, held in the elementary school's activity room. A chipper, blonde fourth grader laid out her sketch for a pyramid-shaped toy patterned with intricate hieroglyphics. Another student decided his toy should be an iPhone, complete with an Angry Birds app on its screen. "Ridiculous," shouted a third child between fidgets. "A dog! A camera!" he insisted, overwhelmed by the possibilities. "No—a dog with a camera!"

"They have high expectations," explained Andrew Scheffel (mechanical engineering '12). "We're going to do our best to get them everything they want."

The McCormick students went to Nettelhorst as part of a senior capstone course in mechanical engineering, Computer-Integrated Manufacturing, that exposes them to the design and manufacture of mass-produced goods. Students in the course take a project from "art to part," using McCormick's prototyping lab and injection-mold machinery to design and manufacture a plastic doodad of their own creation.

When the course's lecturer and lab instructor, Michael Beltran, was approached by Nettelhorst parents about a partnership, he saw an opportunity for learning on both sides. "It's like working with a real client, but your client is 10," Beltran says. "That's a fun challenge for McCormick students, and it also allows us to introduce Chicago Public Schools children to the basics of engineering. It's a win-win."

Under Beltran's guidance a small group of former Computer-Integrated Manufacturing students started visiting the fourth-grade classroom

Above: Michelle Gunderson, a teacher at Nettelhorst Elementary School, watches a computer demonstration with her students. Right: Michael Beltran (top) and Andrew Scheffel (bottom) brainstorm ideas with Nettelhorst fourth-graders.

Above: Members of Northwestern's Society of Hispanic Professional Engineers prep Evanston Township High School students for the Science Bowl. Right: Eliza Bifano (mechanical engineering '12) demonstrates a milling machine for elementary school students during a tour of the Ford Motor Company Engineering Design Center.

last fall, making slide presentations and doing demonstrations, laying the groundwork for the project to come. They started with the basics—What is engineering? What is a solid? How does a mold work?—before moving on to specifics of their project: Will the plastic be thin or thick? What shapes work best in a mold?

> "I really enjoy what I do, and I like sharing it."
>
> TRAVIS JOHNSON

When winter quarter arrived, a new class of McCormick students took the reins. Working in groups, Northwestern and Nettelhorst students agreed on their projects, and the McCormick students set to work designing them. In February, as the highlight of the project, the younger students visited McCormick for a tour of the Ford Motor Company Engineering Design Center, including the shop where their toys would be created. At the end of the quarter, the students returned to collect their toys.

While one of the goals of the Nettelhorst project was introducing elementary school students to science, it was just as valuable to introduce them to the idea of college, says their teacher, Michelle Gunderson. "Many students come from backgrounds where it's not assumed they'll go to college," she says. "Just having this presence in our classroom is a wonderful learning opportunity for kids in an urban school."

OUTREACH WHERE IT COUNTS

Bringing science into schools is fun and rewarding work for many McCormick students—especially when they are able to engage minority and underprivileged groups in science, technology, engineering, and math (STEM) fields.

That's the mission one wintry Saturday afternoon as a group of Hispanic teenagers gather in a first-floor lecture hall in Tech. They chat over slices of pizza before tentatively taking their seats in the front row, where clean notepads and buzzers await them. Two Northwestern students take their spots at the front of the room and flip open their practice test books for the US Department of Energy Regional Science Bowl. "Toss-up. Chemistry. Multiple choice: Which of the following is not true?" reads Jesus Flores (mechanical engineering '13).

The teens stare anxiously at their notebooks, pens tapping, as the possible answers are read. "Don't get overwhelmed," says Tonantzin Carmona (political science '12). "Focus on the key words. If you have to take a guess, answer with confidence. It will intimidate the other team."

Carmona and fellow members of the Society of Hispanic Professional Engineers (SHPE) meet regularly with this group, the society's junior chapter from Evanston Township High School (ETHS). Most of the year they organize events, plan for conferences, and help the high schoolers navigate their way to college. But in January and February their focus turns to the Science Bowl, a *Jeopardy*-like competition in which kids are quizzed on biology, math, energy, and other topics.

With more than 10,000 students nationwide participating in the Science Bowl, the ETHS team is up against some stiff competition. But these weekend practice sessions seem to be making a difference: Last year the team placed first in the regionals and went on to compete in the National Science Bowl in Washington, DC. More important, high school students are becoming engaged in the sciences. "Science was never something I thought about doing outside of school," says ETHS junior Brenda Martinez. "But SHPE made it more interesting to me. It's nice to have mentors from Northwestern who help us."

Through such outreach activities student groups like SHPE and the National Society of Black Engineers are trying to reach students like Martinez—with good reason. According to the National Action Council for Minorities in Engineering, just over 6 percent of engineers in the United States are of Hispanic descent; only 5 percent are African American. To increase these numbers, these national student organizations encourage members to partner with local high schools, creating a web of support that gets kids engaged early and keeps them on track through college.

Many McCormick students see this as a powerful connection, particularly because they lacked similar mentorship during their high school years. Engineering was never presented as an option at the public high school Lamar Richards (mechanical engineering '14) attended on Chicago's South Side. He knew he wanted to work with cars but came upon engineering only by chance, while searching the Internet for jobs. "When I was in elementary school I used to think engineers were people who worked on trains," Richards says. "There weren't engineering courses at my high school. It was something I had to seek out on my own."

Now, as NSBE's precollege initiative chair, Richards works to find ways to introduce young

African Americans to STEM careers. The student group has hosted open-campus events for middle and high school students and has gone door to door passing out information about college and financial aid. SHPE also hosts several daylong events where dozens of middle and high school students experience engineering-related fields through tours, demonstrations, and talks with faculty members.

SCIENCE DAYS

McCormick student groups have found other opportunities to bring science into elementary schools, sometimes finding inspiration in surprising places. In one case, a children's book was the impetus for what has become a long-standing outreach program. *Boing-Boing the Bionic Cat* tells the story of Daniel, a young boy who loves cats but is allergic to them, and his neighbor, a kindly engineering professor who builds Daniel a bionic cat with fiber-optic fur, computer-controlled joints, electronic eyes, and ceramic-sensor whiskers.

More than a decade ago, Leah (Lucas) Lavery (materials science '01) read the book and was inspired. She raised money, put together an outreach kit, and began making arrangements for her student organization, the Materials Science Club, to visit local elementary schools. After each visit classes would receive copies of *Boing-Boing the Bionic Cat.* "I wanted to start a tradition," says Lavery, who now works in product development at PARC. "I really enjoyed those visits."

The tradition has continued: Through its MatSci Exposing Students to Science (MESS) program, the Materials Science Club continues to conduct outreach in Evanston and Skokie elementary schools. In November the group presented demonstrations at Dawes Science Saturday, a science event for families at Evanston's Dawes Elementary School. In front of dozens of wide, safety-goggled eyes, the McCormick team dipped flowers in liquid nitrogen and shattered them. "They loved it," says Danni Jin (materials science '13), chair of the MESS program. "It's great to see the kids asking questions and being curious about science."

The Materials Science Club wasn't the only McCormick student group at Dawes Science Saturday. Just down the hall students from Northwestern's SHPE chapter impressed the elementary schoolers with a do-it-yourself project involving glue, detergent, and food coloring. "None of the kids had ever attempted to make something like Silly Putty," says SHPE president Cecilia Silvestre (manufacturing and design engineering '12). "They had all heard of it, but they thought it was some chemical thing you could make only in a factory."

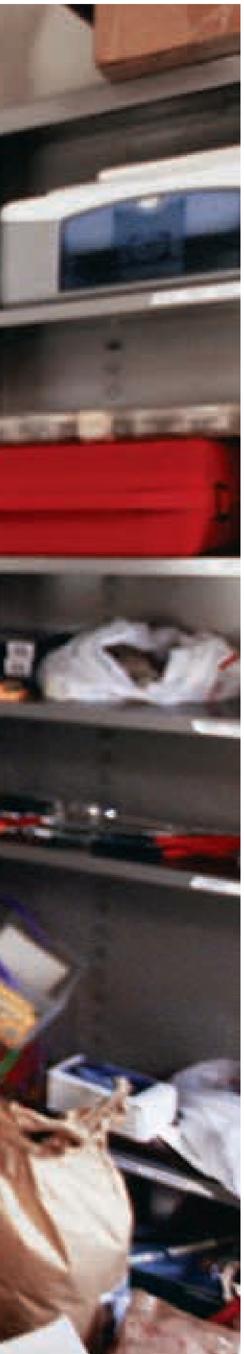
To a 6- or 10-year-old, these activities might seem more like playtime than education. But that's partly why they are so successful, says Johnson. "Growing up, I took part in science fairs every year," he says. "It's what got me started on my path into the sciences. I really enjoy what I do, and I like sharing it."

And the take-away message is powerful, even if the students don't choose a future in science. "We want to expose them to what college is and what engineers do," says Beltran. "The point is to get them excited, to let them see they can do anything they want in life." M Sarah Ostman

Watch a video about McCormick's outreach programs at www.mccormick.northwestern.edu/magazine.

ALL IN A DAY'S WORK

Undergraduate **Sam Malin** knows that to make a difference, you need to **get your hands dirty**



Edzo's Burger Shop has no problem attracting Northwestern students in search of an after-class nosh. But it's not hunger that has brought Sam Malin to the downtown Evanston hot spot on this cold, wet afternoon. In fact, he's not even inside the restaurant but on the roof. More precisely, he's perched atop a metal exhaust vent that puffs greasy burger fumes out of the kitchen and into the cold air.

Malin has come to Edzo's to conduct an energy audit, an assessment that determines how much energy a building uses and suggests ways to lower consumption, such as using low-energy lightbulbs—or in Edzo's case, a new ventilation system. The vent that is good at sucking the fryer fumes out of the kitchen, Malin explains, is also unfortunately successful in taking the building's heat along with it.

Malin is trying to find out why this happens, but the elements are against him. Raindrops pelt him as he squints, scanning the vent for its model number. Shielding his notebook from the pummeling rain, he holds his breath and leans into the hot stream of air. "Next time I should probably ask Eddie [Lakin, Edzo's owner] to turn off the exhaust," he says. "We engineers aren't always doing the most glamorous things," he adds, "but they're all important."

Few things are more important than sustainability to a motivated group of McCormick students involved in the campus organization Engineers for a Sustainable World. Malin is copresident of the group, which has garnered attention with projects like the Tiny House, a 128-square-foot, zero-net-energy house that can operate completely off the grid (see photo on page 41).

Sustainability wasn't always Malin's passion. As a high school student in Rye, New York, he was more of a math kid. He was fascinated by Fibonacci and the golden ratio, a number (about 1.6) that can be used to explain everything from the spiral on conch shells to the patterns by which people seat themselves in an empty auditorium. Malin planned to pursue these interests with a double major in mathematics and psychology.

Then, early in his freshman year at Northwestern, Malin was introduced to Engineers for a Sustainable World. At that time ESW was trying to convert Northwestern's intercampus buses to run on fryer oil from University dining facilities, and they were looking for helpers. Both Malin and ESW were in luck: Malin was already a pro at vegetable oil–powered automobiles. In high school he had converted his diesel Volkswagen Jetta to run on vegetable oil. From filtering out sesame seeds from a Chinese restaurant's waste soybean oil to diluting it with kerosene to get the oil to just the right consistency, the project was a crash course in the mechanics of green technology. (It also affected his social life: Malin admits that at least one date was ruined by soybean-induced engine trouble.)

Through ESW Malin's interest in sustainability skyrocketed. Shortly after the bus conversion project, he became involved with energy audits. Working with professional energy consultants, Malin and other ESW members have inspected not just burger joints but also sorority and fraternity houses and even an Evanston municipal building, noting dated lightbulbs, inefficient freezers, cracked windowsills, and other inefficiencies that cost both the owner and the environment. The group can put a dollar figure on these energy losses, showing owners how environmentally friendly renovations can pay for themselves. (The owner of Edzo's, it turned out, can save more than $700 a year and reduce his carbon footprint by 9,400 pounds per year by implementing the team's recommendations.)

Malin will graduate in June with a bachelor's degree in civil engineering with an architecture focus and a master's degree in mechanical engineering through the department's energy and sustainability program. During school breaks Malin has found ways to complement his studies and gain practical experience. Last summer he completed an internship at a solar energy company in Greenwich, Connecticut, where he researched incentives various states offer for solar energy projects.

In addition to all this hard work, Malin has also found time for pursuits outside the sciences at Northwestern, such as performing in a dramatic production. "I had never acted before," Malin says. "It was a great opportunity to do something totally different."

This spring Malin is again exploring new opportunities as he goes to work in the lab of Eric Masanet, a sustainability expert who recently arrived at Northwestern from the University of California, Berkeley, and Lawrence Berkeley National Laboratory. (Masanet is also an alumnus, having received his MS in mechanical engineering at McCormick.) Malin will research ways to measure and compare the environmental impacts of different building materials through life-cycle assessments.

"A life-cycle analysis looks at all the energy components that go into a product or process, from manufacturing the parts to assembling them and transporting them," Malin says. "It's about tracing a product all the way back so you get a complete look at its carbon footprint. It's a very powerful tool." For example, Malin says, while concrete making is extremely energy intensive, the material could actually save energy over the course of its lifespan, because buildings made with concrete have a higher thermal mass and can better regulate building temperatures.

While Malin continues to build his expertise in efficiency and energy consulting, he has started exploring how he might apply his interests to the business world. "I've become more interested in sustainability as a corporate mentality," Malin says. "How to change corporate strategy to incorporate sustainability and be socially responsible."

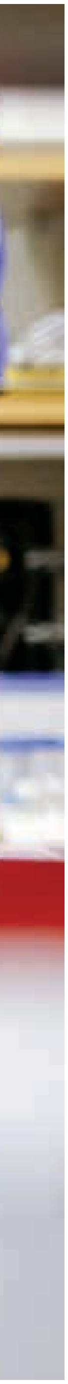
Ultimately, Malin is keeping an open mind, ready to take on new challenges as they present themselves—much as he has approached his work in sustainability at McCormick. "My McCormick experience has really been about getting interested in new things and changing directions," he says. "I'm always open to trying something new." M Sarah Ostman

PARTNERING

Above: Phil Messersmith (left) and graduate student Tadas Sileika in the lab
Right: A set of polymer samples coated with an experimental polymer designed to prevent bacterial attachment and biofilm formation

WITH INDUSTRY

Faculty and students find new innovations through corporate-sponsored research



Each year more than 90,000 people in the United States die from hospital-acquired infections. The irony isn't lost on the hospitals, which have responded with efforts ranging from hand-washing campaigns to the elimination of unnecessary invasive procedures. Other solutions remain elusive, however. For example, catheters left in patients often cause infections: the devices either become populated with bacteria or, in the worst cases, help spread infection into the bloodstream. The consequences can be deadly.

"That's where my group comes in," says Phil Messersmith, professor of biomedical engineering and of materials science and engineering.

Messersmith and his research group are experts in surface coatings and the chemistries used to apply them. Over the past several years they have worked to develop an antibacterial coating to help prevent device-related infections. These efforts, however, have not been funded through traditional governmental routes. The funding came from Baxter Healthcare Corporation in a multidisciplinary research and innovation alliance with Northwestern. During the three-year collaboration Baxter funded more than 20 research projects throughout the University, from Messersmith's coatings to an automated system that checks IV bags.

While the majority of University research funding comes from governmental sources, corporate-sponsored research represents a growing opportunity for McCormick professors. More than 10 percent of research at the school is now funded by corporations. These alliances with the corporate world provide funding for graduate students to conduct basic research and give them and their professors visibility into practical applications.

"It's mutually beneficial," says Richard Hay Jr., director of corporate relations at McCormick. "There is a lot of concern that basic science isn't being translated into useful applications, and some companies have reduced their investment in internal research and development. This provides benefits for everyone."

Corporate-sponsored research is spread across many different specialties at McCormick and covers applications ranging from biomedicine to aerospace. Potential collaborations develop in several ways. The school's Office of Corporate Relations sponsors a series of seminars throughout the year where industry leaders can meet and learn about faculty research. Sometimes researchers are approached by companies interested in gaining access to the latest technology and the best minds in the field. The agreements are coordinated by the Office of Corporate Relations and Northwestern's Innovation and New Ventures Office and Office of Sponsored Research. In recent years the offices have worked together to streamline the process. "Collaborative research agreements are now much easier to put into place," Hay says. "We work together to come up with win-win scenarios."

Once an agreement is signed, the researcher—armed with three to five years of funding—gets down to work.

Developing antibacterial coatings

When the Baxter agreement was initiated in 2009, Messersmith traveled to the firm's Round Lake, Illinois, offices and met with a small group of scientists there. Messersmith explained his research in natural adhesives for medical solutions: he had developed an adhesive

Q&A

Norbert G. Riedel,
corporate vice president and chief science and innovation officer, Baxter International Inc.

Over the past three years, Baxter has funded more than 20 research projects at Northwestern as part of a multiyear alliance. Why did Baxter choose to partner with Northwestern on research?

Northwestern has a very strong research base, an outstanding engineering school, and an excellent reputation in medicine, nanotechnology, and materials sciences. I believe, after almost 20 years of experience, that we have a unique relationship with Northwestern. That is one of the keys that keeps this relationship productive. The culture matters. There truly is a connection.

How are potential research projects chosen?

We send out requests asking investigators to submit brief proposals concerning their research. We select proposals in which we have a particular interest and ask investigators to write up a larger description of their research. Then we make funding decisions. The criteria are based on not only the scientific merit of the work but also potential fits with our strategic orientation with respect to our portfolio of products. We never ask anyone to do particular research tailored to our needs. We are very respectful of the University's academic freedom. We tap into research that would be done anyway and look for work that is a good fit with our organization.

Baxter has scientists on staff. Why do you need the help of McCormick researchers?

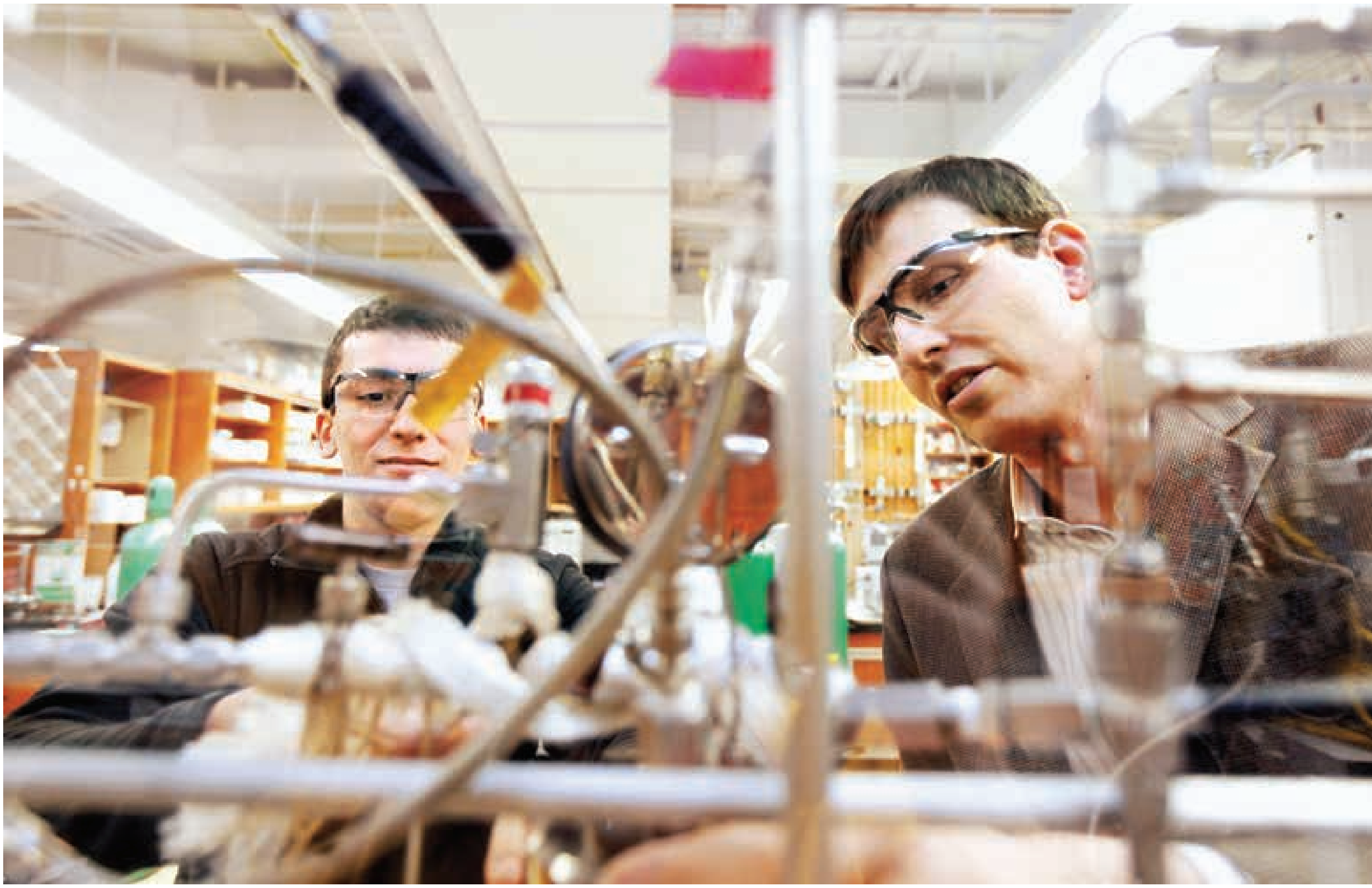
Baxter is much more focused on development, particularly later-stage research programs for which the proof of principle has been accomplished. Most of the basic research has already been done. We don't have an internal research engine for early-stage exploratory work that is about discovering new ideas and principles. Universities are the ideal breeding ground for that. It's where most of the innovation occurs in our country. I would never be able to replicate that internally. I'm much better off tapping into that through partnerships like the one we have with Northwestern.

How does Baxter's proximity to Northwestern [the firm is based in Deerfield, Illinois] benefit the partnership?

It benefits both sides. When you have these kinds of programs and relationships, they are dependent on frequent interaction and good philosophical alignment. Proximity, in my view, is essential. These partnerships require a lot of interaction between scientists. It's extremely hard to do if you are 3,000 miles away from each other; it typically fails. This interaction also offers Northwestern researchers a more translational orientation in their research. It's a great opportunity for Northwestern to understand how an organization like ours goes about these programs.

Baxter has been involved with McCormick's entrepreneurship course NUvention: Medical Innovation, and you are a member of the McCormick Advisory Council. How do these connections complement the research alliance?

They all really connect. In NUvention: Medical Innovation, students look at innovation and ask how an idea can become a new product and company. The orientation is toward the marketplace. In that case, the involvement of Baxter is helpful. Our discussions in the McCormick Advisory Council often relate to what the curriculum should look like or what the strategic focus should be. There we try to make the work at McCormick most relevant. These connections are all oriented to creating more proximity between industry and academia.



Graduate student Dario Prieto and Justin Notestein (right) discuss modifications to a high-pressure reactor for testing new catalysts.

that mimics the properties of both a gecko and a mussel to stay sticky under water, as well as a mussel-inspired glue for fetal membrane repair. Perhaps his skills would be useful in developing a new coating for catheters, he suggested.

"Our expertise helps them solve problems," Messersmith says. "We get funding, and we get to publish in our usual way. Everybody benefits."

Messersmith and graduate student Tadas Sileika have spent the past two years researching the chemistry for an antibacterial coating and discussing the problem with a third partner: a microbiology group at the Centers for Disease Control and Prevention in Atlanta, which brings expertise in infectious diseases. While there are antibacterial coatings on the market, Messersmith hopes to create a polymer surface coating combining both antibacterial and antifouling elements (the latter prevent organism attachment) that might remain effective over long periods. In this third year of funding, he hopes to finally make that coating a reality.

"This is the critical year," Messersmith says. "By the end of this year we hope to identify a coating composition that Baxter can then move into product development."

One of the best parts of the project has been working with—and learning from—Baxter's scientists. Sileika has a Baxter scientist on his thesis committee, and Messersmith says he's learned from the scientists' industrial perspective. And still he retains his academic freedom: he's published a paper in a scientific journal that resulted from Baxter-funded research.

"There is common ground between our needs and their needs," he says.

Creating new chemical processes

For Justin Notestein, assistant professor of chemical and biological engineering, the Dow Chemical Company's $250 million commitment to research and development at 11 universities was a boon. He'd already worked with the company on the Dow Methane Challenge—he was part of a team trying to find a way to turn widely available methane into useful chemical feedstocks—and the problems in which Dow was interested related directly to his research in designing materials and gaining a new understanding of catalysis to create sustainable alternatives to chemical processes.

Now Notestein is the primary investigator on two Dow-funded projects. The first involves epoxy resins, which are used as coatings and are increasingly used in high-performance areas such as electronics packaging. Among other challenges, one of the current methods of producing the resins can leave behind chlorine, and Dow and its customers want a cleaner way to do it. Notestein is leading a team of five professors developing catalysts to make the resins in reactions not involving chlorine, as well as working to understand how these catalysts function. "There is nothing on the shelf that will do it," he says. "This is something I've been working on since graduate school. It's a difficult problem—and a great challenge for an academic researcher. If we could get this to work, it would be broadly applicable."

The second project will look for new ways to create methyl methacrylate (MMA). This material is used in many products, including clear sheets of polymethyl methacrylate, known by a variety of trade names including

Q&A

William F. Banholzer, executive vice president, ventures, new business development, and licensing, and chief technology officer, Dow Chemical Company

Dow will give $25 million in research and development funds to US universities in 2012. Why is Dow interested in investing in science and engineering research at universities, and how does this fit with Dow's R&D program?

Our objective is to create products that create value for society. How we do that is up to us. We can fund work in universities and national labs, we can license technology, or we can hire our own people. As big as Dow is, we're not going to have all the skills needed to address all the problems we're trying to solve. We have a lot of resources, but we don't have all of the best ideas, so I think there's a natural partnership with universities.

We also hire a significant number of PhDs in chemistry and engineering for research and development. In academia it's getting harder and harder to get funding in traditional fields, particularly in chemical engineering subjects like separations and thermodynamics. They aren't sexy, but they are as fundamental as ever. I was worried that the current workforce wasn't getting trained in fields that are going to remain important to us over the next 100 years.

We have some hard problems and want the best minds to work on them. Many of those are at universities. The dialogue between industry and academia spawns the next generation of products. Having a robust interaction with universities is a way to keep the United States competitive.

How did Dow identify the McCormick School as a strategic partner?

We have a long history with Northwestern. Many of our employees are alumni, and it has a tremendous reputation in engineering, materials science, and chemistry. Northwestern has been a great partner in our intellectual property agreements.

McCormick has received $2.36 million from Dow for five research projects. How are potential research projects chosen?

Every year we have an exercise where we rank the problems we're trying to solve. We ask: What programs have the biggest return? What is the best team we could assemble on this? In some cases we do everything inside. In others we think the projects could benefit from the skills of people in academic and national laboratories.

How does Dow benefit from its partnership with McCormick?

We work with schools like McCormick so that we have world-class people—our future employees—trained by world-class faculty. The concrete result is that we will have a well-educated workforce trained in areas that will be of interest to society. If we can actually come up with a better electrolyte or better route to materials we need, those are things we hope we can commercialize.

We're continually trying to engage academia. Most students today want to work on projects that make a difference in society. If you're in an academic environment, technology doesn't benefit society until it is commercialized. The closer the interaction is between large companies and academia, the better.

Plexiglas®. Dow uses MMA in a wide range of copolymer applications that include coatings, resins, personal-care products, and plastic additives. The goal of the Dow-sponsored research is to find an alternative way to make MMA starting from a biomass-derived raw material. Professors from the chemistry and chemical and biological engineering departments will work together to develop a practical method involving biological feedstocks. Laboratory studies, with luck, will someday lead to an actual industrial process. "This is very interesting from a chemical point of view," Notestein says. "It should work, but nobody has been able to implement it. It's a discovery mode of engineering."

Taking lab chemistry and turning it into a viable chemical process takes a considerable amount of time. Subtle changes in conditions must be understood before a system can be moved from the lab to pilot program and, ultimately, full commercial scale. Dow is funding the project for five years—enough to fund a graduate student through his or her PhD. "Because they've taken the long view on this, we can take the first two years to develop catalysts from the ground up," Notestein says. "It's a very good time frame, and it trains the student in the types of skills that companies like Dow need." In fact, Dow officials have said they funded this research for just that reason: to give students the right chemical engineering skills.

Notestein is bringing those skills to undergraduates, too. He has developed a new course called Chemical Product Design, in which he uses examples from Dow's search for new innovations. The projects result in real applications while still giving Notestein and his students the room for intellectual exploration.

"It's a set of grand challenges that are relevant to the chemical industry," he says. "They've left it very open for us to guide it."

Wing Kam Liu

Designing better tires

The Goodyear Tire & Rubber Company and McCormick recently began an open innovation research collaboration that is attempting to answer a question the entire industry faces: How can we make an all-season tire that has minimal rolling resistance? The tire can't be too stiff or it won't gain enough traction in bad weather, but it can't be too soft either or it will require more energy to turn. The Transportation Research Board estimates that if tire-rolling resistance were reduced by 50 percent, 10 billion gallons of fuel (8 percent of our total national fuel expenditure) could be saved each year.

Researchers at McCormick suggested computationally designing a next-generation tire material that could help reduce the energy consumption of vehicles. The project was ideal for Wing Kam Liu, the Walter P. Murphy Professor in mechanical engineering. Liu's expertise in digital-based multiscale modeling of hard materials translated well to soft materials like rubber. "I was ready to work on this project," he says, "but I needed a good team."

Together with Catherine Brinson, chair of mechanical engineering and Jerome B. Cohen Professor of Engineering in materials science and engineering, Liu assembled a multidisciplinary lineup. Q. Jane Wang, professor of mechanical engineering, looked at the makeup of the tire, studying the nanoscale friction between rubber and carbon black, a material often added to tire rubber to stiffen it. Research assistant professor Dmitriy Dikin used a scanning electron microscope to study the materials at the nanoscale, and Wei Chen, professor of mechanical engineering and Wilson-Cook Endowed Professor in Engineering Design, provided expertise on design principles and computational representation of microstructure. Brinson created lab-scale samples to characterize the mechanics of the rubber–carbon black interactions and also worked with Liu and Chen on multiscale predictive modeling.

"With all this information we are building a computational model to virtually design a material with the right performance," Liu says. "We have the right team of experts at Northwestern that work well together and with Goodyear researchers to accomplish this goal."

So far the team has developed computational design methodologies, several of which Goodyear is already using. Still, a solution isn't imminent. "It's a grand challenge in materials science," Brinson says. "If I make one tiny change in the material's composition, can I now predict exactly how it's going to affect the bulk properties of the material? The answer is no. We're trying to fundamentally understand the changes at the nanoscale and predict how those changes propagate upwards to impact bulk performance."

Over the next several years, the group hopes to synthesize more designed materials for testing in the lab. Eventually their goal is to use this multiscale modeling to design new tire tread materials. As with the other projects, these computational design theories aren't just for Goodyear: they can be applied to many different materials systems. And these researchers, too, enjoyed working with Goodyear scientists and sending students and postdocs to their labs.

"It's key to integrate theory, small-scale lab experiments, and the real world," Liu says. "Everyone loves it. We are opening a new dimension in technology." M Emily Ayshford

CHANGING SHAPES

Graduate student Aaron Stebner finds a home for his research—and a passion in the classroom

When Aaron Stebner was growing up near Akron, Ohio, the letters "EDC" stood for Electric Device Corporation. This company, started by his grandfather, a World War II veteran and self-taught engineer, manufactured automated test and manufacturing equipment for the circuit breaker industry. It also sparked Stebner's interest in engineering.

"My grandfather used to take me to work when I was little. He'd sit me down on a table with a pile of alligator clips, and I'd just build things," Stebner recalls. "And my father used to do all kinds of projects with me around the house. My family was really my inspiration."

These days the family business is gone; the company was sold in the 2000s. And the letters "EDC" now mean something very different for Stebner: Engineering Design and Communication, a two-quarter course sequence required of all McCormick freshmen. Stebner, a PhD fellow in mechanical engineering and an adjunct lecturer at the Segal Design Institute, has been teaching the course since 2009.

Stebner's expertise is in shape memory alloys, a type of metal that can "memorize" a shape and return to it under some kind of stimulus, such as a change in applied load or temperature. These materials open up vast possibilities. At the simple end of the spectrum, picture a paper clip that, after being unbent, springs back to its original shape when heated. At the complex end, imagine self-healing armor for vehicles and humans, morphing aircraft that change shape depending on their speed and altitude, and artificial heart valves that can be deployed through a catheter instead of being implanted through open-heart surgery. All of these are shape memory alloy projects currently under development that Stebner has worked on.

It's easy to understand why Stebner became intrigued."I grew up on *Transformers* and *Voltron,* before the revivals," Stebner says. "Shape memory alloys allow these childhood fantasies to become reality, only for purposes that better our society rather than for entertainment."

While Stebner wanted to be an engineer from an early age—he started working in his family's business during high school—there was a time when he almost called it quits. After a tumultuous few years pursuing his undergraduate degree in New York and Ohio, Stebner dropped out of school, moved to Pittsburgh, and started deejaying and working in a nightclub. It didn't last. "I realized you can't just spend your life in a nightclub," Stebner says. "When it becomes your job, it stops being fun."

So he went back to school, finishing bachelor's and master's degrees at the University of Akron. Doors started opening for Stebner when he won a fellowship at the NASA Glenn Research Center in Cleveland. He began working with shape memory alloys for aerospace applications, an important area of research that could lead to lighter, more fuel-efficient aircraft.

"It was an incredible opportunity," Stebner recalls. "I drew upon my education and experience from my family's company to design and build new test equipment for NASA's high-temperature shape memory alloy program. Then I got to use my equipment to develop brand new actuation devices for making aircraft structures change shape during flight."

After receiving his master's degree, Stebner accepted a job at TZ Inc., a Chicago-based start-up that made shape memory alloy–based latches and locks—devices that allow people to unlock their homes with their cell phones, for example. But it wasn't long before Stebner set his sights on Northwestern. "I realized my desire to learn more about shape memory alloys was burning strongly, and I knew the best way to do that was to commit to a PhD program that employs some of the world's best professors in the field, namely Cate Brinson, David Dunand, and Gregory Olson," Stebner says, citing three McCormick faculty members active in the field.

Stebner's opportunities at McCormick have been plentiful. He landed a spot in Brinson's lab, where he has worked on aerospace, automotive, defense, and medical applications of shape memory alloys. He has benefitted from several Northwestern fellowships, including ones from the Predictive Science and Engineering Design Program and the Initiative for Sustainability and Energy at Northwestern, as well as a dissertation fellowship from the endowment of Toshio Mura, a professor emeritus of civil and environmental engineering and mechanical engineering who passed away in August 2009. "These programs have provided me the freedom to pursue many different research paths during my time here and to continue to collaborate with colleagues at Los Alamos National Lab, NASA, and Boeing," Stebner says.

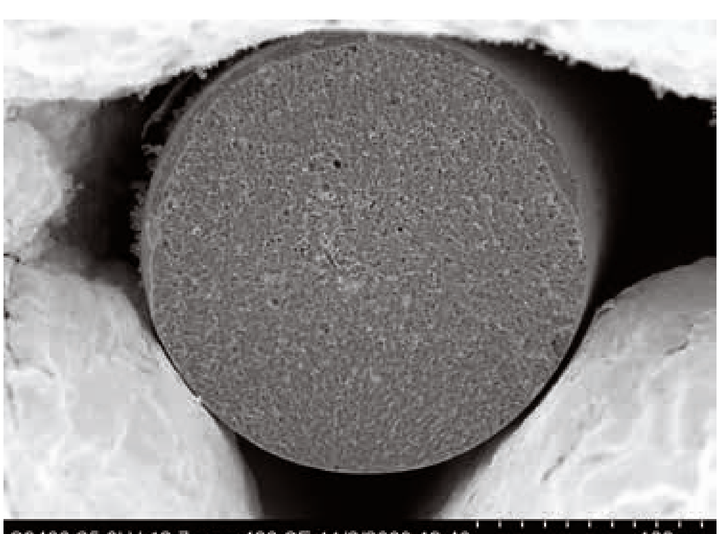
His adjunct position at the Segal Design Institute has allowed Stebner to branch out into teaching. "I came to Northwestern with seven years of industry experience," Stebner says. "The courses in Segal, especially EDC, are structured so I can share my experiences with the students through hands-on design and product development for real clients."

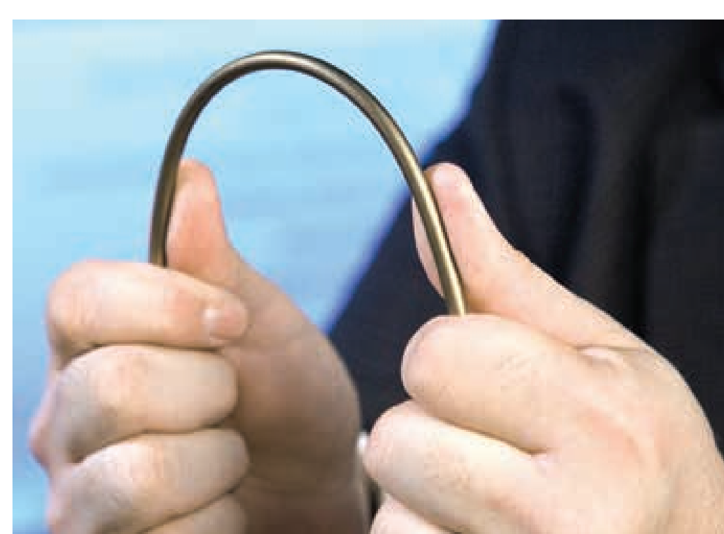
Stebner's EDC students have worked on a dozen shape memory alloy projects for client companies. In a project with Boeing and Dynalloy, a shape memory alloy supplier, students redesigned the mechanism that deploys oxygen masks when the cabin pressure drops in an airliner. Their shape memory alloy devices were 60 percent lighter than the air-powered actuator used on the Boeing 747 today; the design could save airlines $200,000 in fuel costs each year the plane is in service, the students found. Other projects have included owl- and hawk-shaped bird deterrents that flap their wings at random intervals so birds don't get used to the commotion, and a jet engine vent that can cool itself off by opening and closing as needed.

In the process of teaching EDC, Stebner has shifted his goals. When he embarked on his PhD, he says, his dream was to return to NASA. After defending his dissertation this spring, Stebner hopes to move on to an assistant professorship at a university.

"The opportunity to get into the classroom and connect with students changed me," Stebner says. "The privilege of watching students blossom and succeed—to have them come back and tell you that something you said one day in the classroom has influenced that success—warms my heart and brings me a fulfillment that I don't get from research alone." M Sarah Ostman

Left: A scanning electron microscope image of a NiTi wire fracture surface
Right: A rod-shaped shape memory alloy





CAREER DAY FOR GIRLS

On February 25, girls from across the Chicago area gathered at Northwestern's 41st annual Career Day for Girls. The event, "Engineering: The Sky's the Limit," brought more than 200 middle and high school girls to McCormick to learn about engineering and applied science through laboratory tours, hands-on activities, and panel discussions. The goal was to share knowledge about science and technology with a group that has historically been underrepresented in the field. "It's important to reach out to girls and show them all that engineering has to offer," says Ellen Worsdall, assistant dean for student affairs.

The efforts seem to be working: When Career Day got its start in 1970, only 4 percent of McCormick students were women. Today that number is 30 percent.

Alumni Profile: **Peter Barris**

A venture capitalist behind some of today's hottest Internet companies, Peter Barris still uses the lessons he learned back at Tech

Above: Peter Barris at Northwestern's Commencement ceremonies
Right: Barris with Groupon founder and CEO Andrew Mason

Wildcat fans know magic can happen on the field at Northwestern football games, but magic happened for Peter Barris in the stands, as well.

A few years ago Barris (electrical engineering '74) was cheering on the purple and white at Ryan Field when a fellow alumnus told him about up-and-coming entrepreneur Eric Lefkofsky. Barris, the managing general partner at venture capital firm New Enterprise Associates, ended up investing in three of Lefkofsky's companies before Lefkofsky introduced him to another idea man: Northwestern alum Andrew Mason (Bienen '03). Mason had started The Point, a website that helped users raise money for philanthropic efforts—with a twist: only after the number of participants reached a "tipping point" did the funding kick in. Barris and his firm were interested and eventually worked with Mason to shift the concept of the tipping point to distributing local daily deals. In doing so, they changed the name to—well, you might be able to guess.

Three years later Groupon has gone public and has been called the fastest-growing company ever by *Forbes*.

"It has been an amazing ride," Barris says.

Barris's success story began much earlier, however—back when he was growing up on the North Side of Chicago. His father, a civil engineer, encouraged him to go that route, too. But Barris had his eyes set on the law—patent law, specifically, which he had heard required an engineering degree. Northwestern had excellent law and engineering schools, so he enrolled as an electrical engineering major. "That's what was up-and-coming from a market perspective," he says.

While at McCormick Barris didn't just hole up in Tech, though: he was a producer of the Dolphin Show, served on the Wildcat Council, was elected into the Deru honor society, and helped manage the spring lakeside festival called Spring Thing. (The event's entertainment: Sly and the Family Stone.) "I had a lot of diverse interests," he says. "I was friendly with both theater students and jocks. I just wanted to take advantage of everything Northwestern had to offer."

In his junior year Barris took a law-focused engineering class taught by a patent attorney. The class proved fortuitous, but not in the way Barris imagined: he discovered that patent law wasn't where his passion lay. He enrolled in the Walter P. Murphy Cooperative Engineering Education Program and began working at a local engineering

"I'm around passionate entrepreneurs every day. It's exciting."

PETER BARRIS

consulting firm, which hired him after graduation. Never content to stay in one place too long, Barris soon began to apply to MBA programs. "I wanted to leverage my engineering degree and knowledge into a business profession," he says.

While a student at the Tuck School of Business at Dartmouth College, Barris came across a letter on a career services bulletin board asking for a technically oriented consultant to work in General Electric's Components and Materials Group. The group was headed by future GE CEO Jack Welch, who had started a program rotating one new MBA through divisions on consulting projects. Barris got the job. "It was perfect for me," he says.

Over the next 10 years Barris moved up the ladder at GE from marketing to sales to general management, mostly within information services, where he helped create start-ups within the company. "I was an entrepreneur within a corporate structure," he says. "That was my first taste of the start-up world."

Barris liked working in information technology, so he left GE and spent the next several years helping turn around unprofitable IT companies. He became known for buying and selling small start-up companies and considered making the move to Silicon Valley or starting his own systems software business. New Enterprise Associates offered to back his business as long as he helped the firm with other companies in which it had invested. Instead, he ended up joining NEA and became managing general partner seven years later, in 1999. "I'm around passionate entrepreneurs every day," he says. "It's exciting. We not only invest in them, we also partner with them to help create successful companies."

Since Barris became managing general partner, NEA's assets under management have grown from $700 million to more than $11 billion. He was recently listed eighth on the *Forbes* Midas List of top investors.

Groupon, perhaps his most notable investment, took a while to get off the ground. Barris and his colleagues loved the concept of using the Internet to aggregate enough individuals to create a "tipping point" that would kick the fundraising campaign into action. But Mason's original concept was aimed toward philanthropy, which didn't translate into a money-making business. Once the team realized the concept could be translated into daily deals, the company began growing, eventually expanding to 10,000 employees. "That includes a number of Northwestern alumni," Barris says. "It's been a rocket ship."

Outside of work Barris still bleeds purple: he sits on the Northwestern Board of Trustees, the board of the Initiative for Sustainability and Energy at Northwestern, and the McCormick Advisory Council, and he's giving McCormick's convocation address this June. "I love the academic environment—teaching and guiding young people," he says. "I find that as I get older, it's motivating to be around younger people who have passion and vision. I'm a big believer in the importance of an engineering education in this country. It's hugely important to the future."

Though the McCormick of Barris's day was very different from the school today—he admits that much of the technology he learned about is now obsolete—its core lessons still apply. "I learned how to solve problems at McCormick," he says. "It taught me how to learn and be comfortable in a business where I'm dealing with technological change all the time. It gave me a foundation to be a critical thinker. Now what I do every day of my life is solve problems."

M Emily Ayshford

Undergraduate engineering *by the numbers*

90
PERCENTAGE OF STUDENTS WHO HAVE AN OPPORTUNITY LINED UP AFTER GRADUATION

1,529
NUMBER OF UNDERGRADUATE STUDENTS

754
AVERAGE SAT MATH SCORE FOR INCOMING FRESHMEN

35%
INCREASE IN FEMALE STUDENTS OVER THE PAST SIX YEARS

20+
STUDENT COMPANIES CREATED THROUGH THE FARLEY CENTER FOR ENTREPRENEURSHIP AND INNOVATION SINCE 2007

75%
STUDENTS WHO PARTICIPATE IN CO-OP PROGRAM OR INTERNSHIPS

35,000
MILES LOGGED BY CONTEST VEHICLES BUILT BY McCORMICK UNDERGRADUATES

300+
JOURNAL ARTICLES COAUTHORED BY UNDERGRADUATES SINCE 2001

8%
GRADUATES WHO GO ABROAD AFTER GRADUATION

40
PERCENTAGE OF UNDERGRADUATES WITH GLOBAL EXPERIENCES

28%
GRADUATES WHO GO DIRECTLY TO GRADUATE SCHOOL

1,873,080
GROSS SQUARE FOOTAGE OF THE ENTIRE TECH COMPLEX

STUDENTS BUILD "TINY HOUSE"

Over the last two years McCormick students designed and built the Tiny House, a 128-square-foot house that encourages sustainable living. It comes with a bed, a kitchen, and a bathroom and can function off the grid. Solar panels produce electricity for the house, which also collects its own water.

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

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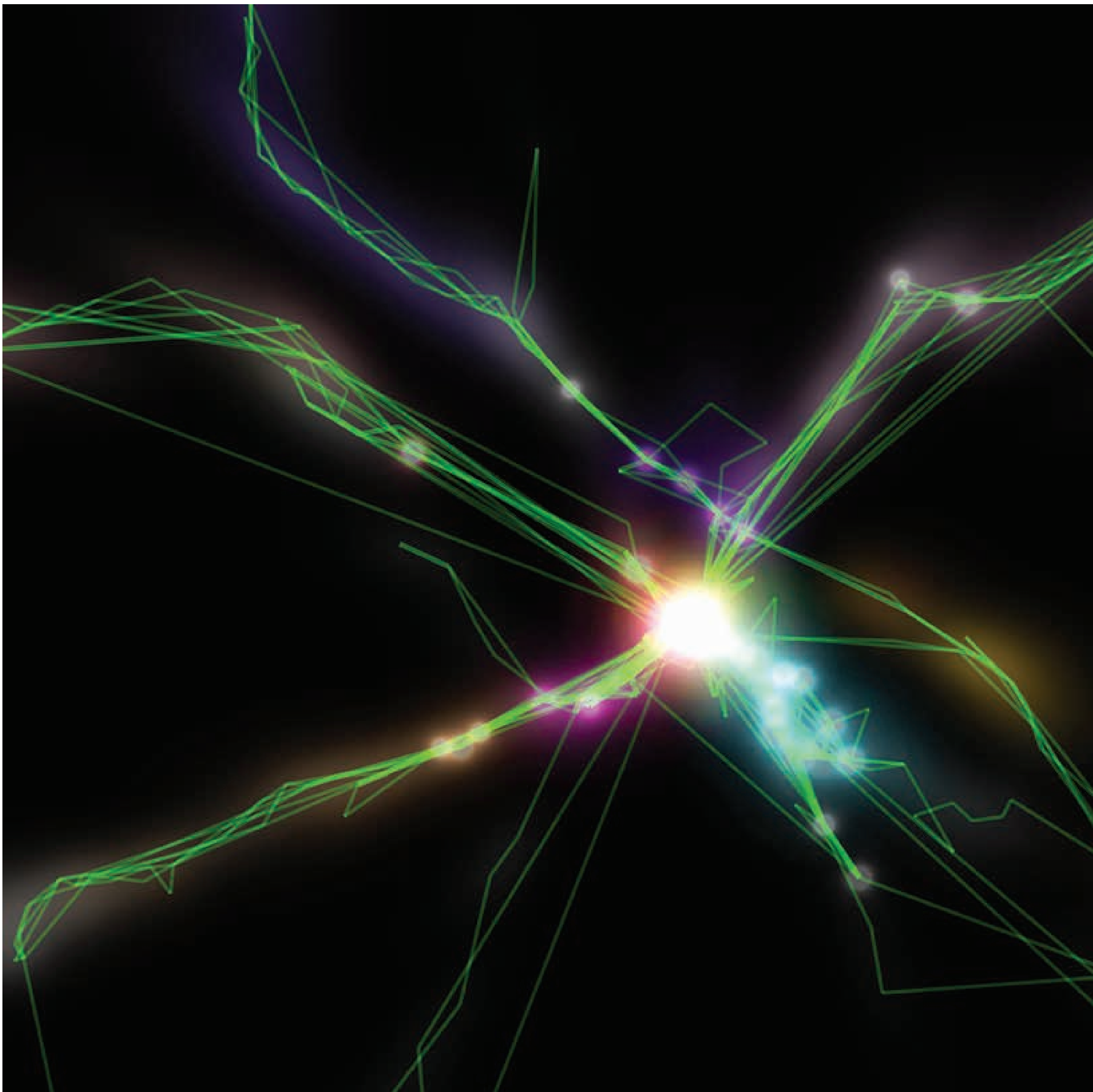
TRACKING HUMAN MOVEMENT

Understanding human movement is essential to addressing technological and policy issues ranging from urban planning to the modeling of epidemics. Here, McCormick researchers trace the travels of a single mobile phone user in Western Europe over nine months. During that time the user placed about 12,000 calls from 427 unique locations. Green lines track the user's movement. Glowing lights indicate frequently visited locations, while the bright core indicates home and work. The colors of the lights indicate dynamically related locations called habitats, while wisps of color on the periphery highlight subsidiary habitats from additional travel. These habitats play a key role in studying human mobility and social interactions.



Courtesy of James Bagrow, research assistant professor in the lab of Dirk Brockmann, associate professor of engineering science and applied mathematics

CLASS NOTES

1940s

Lester Crown ('46) and his family were awarded the Andrew Carnegie Medal of Philanthropy.

1950s

Edward D. Henze ('50) of Albany, Oregon, enjoyed his career as a research and development engineer in five states east of the Mississippi, then ventured west for 15 years in Jackson Hole, Wyoming. Now he is "safely put to pasture in an Oregon retirement village."

L. Broas Mann (MS '50) of Shelby Township, Michigan, retired after 50 years as a Chrysler research engineer and consultant. With inspiration from former Northwestern professor Burgess Jennings, Mann spent much of that time with the Chrysler Automotive gas turbine program.

James F. Gibbons ('53) of Portola Valley, California, has taught engineering at Stanford University for more than 50 years. A researcher, educator, and administrator committed to educational and technological innovation and developing relationships between academia and industry, he received the Founders Medal from the Institute of Electrical and Electronics Engineers last August. His vision and leadership have bolstered Stanford's engineering programs and helped fuel worldwide innovations in Silicon Valley.

1960s

Charles A. Wentz Jr. (PhD '62) of Edwardsville, Illinois, was appointed to the Southern Illinois University School of Engineering advisory board.

Joseph L. Schofer (MS '65, PhD '68), associate dean at McCormick, received the 2011 Roy W. Crum Distinguished Service Award from the Transportation Research Board of the National Academies in recognition of his transportation research.

James L. Funk ('66) of Charleston, South Carolina, published his debut novel, *Long Walk Home: A Civil War Infantry Soldier's Love Story* in 2011. Funk has enjoyed several careers since his graduation from Northwestern. He spent 18 years in the automotive industry, becoming an executive with the Ford Motor Company. He then became a builder and restorer of residential homes and a golf course owner, builder, and operator in Michigan. Now Funk is a writer. In addition to his new novel, he wrote and published a historical nonfiction book, *Three Rivers Form an Ocean: Vignettes of Life in Charleston, South Carolina,* in 2003.

Craig Martin ('66) of Seattle, a writer, had an excerpt from his play *Benvolio—In Fair Verona, the Other Tragedy* selected for publication in *Gay City: Volume 4: At Second Glance* in 2011. The play is a backstory to Shakespeare's *Romeo and Juliet.* Martin's short story "Broadway" was in *Gay City: Volume 2* and was selected for an Editor's Choice Award.

1970s

Cyril B. Tellis (MS '71, PhD '75), a former research and development manager for Union Carbide, has joined Invictus LLC, which plans to design and build a cracker plant near Montgomery, West Virginia, to produce natural gas.

Donald P. Monaco ('74, MS '74), principal owner of Monaco Air Duluth, has joined the board of directors of Next 1 Interactive.

Che-Hang Charles Ih (MS '79) of Rancho Palos Verdes, California, a Boeing associate technical fellow, received the company's annual Special Invention Award. Ih, one of Boeing's top scientists, was part of a team that invented an approach that is under protection as a trade secret but was recognized among thousands of Boeing inventions in 2011.

Virginia M. Rometty ('79) became president and CEO of IBM in January. She was listed among *Forbes* magazine's "100 Most Powerful Women" last September and among "Twelve Global Executives to Watch in 2012" by the *Wall Street Journal* in December.

Jonathan S. Turner (MS '79, PhD '82), a faculty member in computer science and engineering at Washington University in St. Louis, received the school's 2011 Chancellor's Award for Innovation and Entrepreneurship.

1980s

Daniel P. Kovacevic ('81, Kellogg '83) was hired as a director of leasing for the Arizona Southwest division of real estate company Whitestone REIT.

Michael Willett ('81) of Reston, Virginia, is a director of engineering in the intelligence solutions division of General Dynamics.

John Z. Kukral ('82) is the founder and head of Northwood Investors, which has closed more than $1 billion in a second offering, bringing its total capital raised to $2.3 billion.

Hsiu-Guo Chang (MS '84, PhD '87), a senior director of Carlyle Asia Investment Advisors, has been named a nonexecutive director of Yashili International Holdings.

Helen S. Kim ('85), chief business officer of NGM Biopharmaceuticals, was appointed to the board of directors of ImmunoCellular Therapeutics.

Kevin E. Calderwood ('86, Kellogg '88), president of Vivisimo, a search and analytics provider, was profiled by *Information Today.*

Christopher Clower ('88), managing director of Borneo Brothers Limited, has joined the board of directors of Australia-based Western Manganese.

Robert J. Kiep ('88) was named senior vice president and chief architect of information technology at Gallagher Bassett Services in Itasca, Illinois.

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Sharmila Shahani Mulligan ('88, Weinberg '88, Kellogg '94) was appointed to the board of directors of Lattice Engines, a sales intelligence software company. Most recently she was executive vice president of marketing for Aster Data.

Yeong-Sam Byun (PhD '89) was named chief executive of LG Siltron as part of an executive reorganization of its parent company, LG Group.

Todd A. Kuiken (PhD '89, Feinberg '90, '91, '95), director of the Rehabilitation Institute of Chicago's Center for Bionic Medicine and Amputee Services, was profiled in *Crain's Chicago Business* for his work constructing computerized limbs.

Suk-Chung Yoon (MS '89, PhD '91), chair of the department of computer science at Widener University in Chester, Pennsylvania, was appointed to a newly created part-time position of special assistant to the president.

1990s

Alicia S. Boler-Davis ('91) was named vice president for customer experience at GM. With GM since 1994, she has served in a variety of positions, including plant manager and vehicle line director/vehicle chief engineer.

Mansour A. Salame ('92) was named to the board of directors of 8x8 Inc., a provider of computing solutions. 8 x 8 acquired Contactual Inc., which Salame formerly served as chairman and CEO.

James Charles Brailean (PhD '93), cofounder, president, and CEO of PacketVideo, received the Distinguished Alumnus of the Year Award from the University of Michigan–Dearborn. He was also appointed to the board of directors of MicroPower Technologies.

In 1999, **Paul Fichter** ('94, MEM '97, Kellogg '97) of Seattle launched Taphandles, a firm that manufactures distinctive tap handles for breweries, and outsources the detailed production work to China, where his company runs a factory with 450 employees. Last fall Taphandles opened a facility for making lighted signs and other displays in Woodinville, Washington, and a plant outside Chicago that prints beer logos on glassware.

Jeffrey Waters (MEM '94, Kellogg '94) was named senior vice president and general manager for the military, industrial, and computing division of Altera Corporation.

The second edition of *Lean Hospitals: Improving Quality, Patient Safety, and Employee Engagement* by **Mark Graban** ('95) was published in November. The first edition earned a 2009 Shingo Research and Professional Publication Award.

John Green ('95) of Naperville, Illinois, works in the Chicago office of Halcrow Inc. as senior rail civil engineer and lead track designer for North America. He also serves as chair of the transportation group of the Illinois section of the American Society of Civil Engineers.

Brian M. Breit ('96) was promoted from senior manager to director at Deloitte Consulting.

Fabian Meier (MS '97) rejoined the GmbH/ Geneva Lab in Zurich, Switzerland, as a senior vice president for audio and video product development.

Craig Witsoe (MEM '97, Kellogg '97) joined Abound Solar in Loveland, Colorado, as president and CEO in November.

Rene Carlos ('98) of College Park, Maryland, was the lead mechanical engineer on last June's successful Small Rocket/Spacecraft Technology (SMART) mission, a suborbital NASA/Department of Defense launch to demonstrate microsatellite technologies.

2000s

Satya Tiwari ('00, Weinberg '00) of Atlanta, **Amit Saraf** ('00, Kellogg '05) of San Francisco, and Sandeep Luke (Weinberg '00) of New York followed traditional paths after graduating from Northwestern, taking investment-banking jobs at Wall Street firms. But a decade later the three close friends reunited to form Surya, a home décor company. In August the company was named to *Inc.* magazine's 2011 Inc. 500/5000 list as one of the fastest-growing privately held companies.

Jeri Beth Ward (MEM '01, Kellogg '01) became the first-ever director of customer experience at Audi of America, where she has worked since 2007.

Allen Capdeboscq (MEM '02, Kellogg '02) was named vice president of financial and capital planning for Peabody Energy. He was vice president of business development.

Matthew Joseph Hertko ('02) was named a partner in the intellectual property practice of Kirkland & Ellis's Chicago office.

Fernando Zumbado ('03) of Houston is a robotic systems engineer working on the Multi-Mission Space Exploration Vehicle as the lead window designer at NASA's Johnson Space Center. Recently he was named the test and verification lead for the Simplified Aid for EVA Rescue (SAFER) project, a self-contained propulsive system for use during extravehicular activity. As part of his educational outreach activities, he joined the first team from Northwestern to fly in the Reduced Gravity Student Flight Opportunities program in summer 2011. He flew a Northwestern flag provided by **Ryan McGuire** ('02). Zumbado recently celebrated his 10th year of working at the Johnson Space Center, where he started as a co-op student.

Jeffrey R. Schell ('04, GSCS '11) of Chicago and Ethan Lipkind (Weinberg '06) of Wilmette, Illinois, created Michigan Rural Healthcare Preservation Inc. to ensure access to health care in rural communities. The charitable organization empowers specialty physicians to develop needed service lines to ensure that health care services remain available for communities in rural parts of Michigan. Schell is the CEO, and Lipkind is general counsel. The network is supported and linked by CareShare, a health care social networking application created by Schell and **Barrett Griffith** ('04). CareShare was featured at the DC to VC: HIT Start-up Showcase, a health information technology venture capital conference.

Weian "Andy" Chang ('05) was awarded the Trudy A. Speciner Non-Supervisory Award for Advancing Environmental Protection by the US Environmental Protection Agency.

Lucy J. Chung ('05) was promoted from copywriter to senior copywriter at AbelsonTaylor.

Sanjay Nangia ('06, Law '09) was named an associate in the San Francisco office of Davis Wright Tremaine.

Michael Scott Arnold (PhD '07), professor of materials science and engineering at the University of Wisconsin–Madison, received a Presidential Early Career Award for Scientists and Engineers.

Regan Blythe Towal (MS '07, PhD '10), a researcher at the California Institute of Technology, was awarded a 2011 L'Oréal Fellowship for Women in Science by the American Association for the Advancement of Science.

Samir Rayani ('09), David Hoffman (Weinberg '09), and Alex White (SESP '09) earned a spot in *Businessweek*'s listing of America's Best Young Entrepreneurs, thanks to the Next Big Sound, a start-up that the trio conceived during a Northwestern entrepreneurship course. The company provides bands with a tool to measure their social media presence. Its service tracks fans' online activity and behavior for thousands of artists and packages the analytics in an online dashboard.

2010s

Kristin Landry ('10) began a master's degree in civil and environmental engineering at Stanford University's atmosphere and energy program in September. She plans to complete her degree in April 2013. She spent the summer at Questions & Solutions Engineering Inc. in Minnesota.

In memoriam

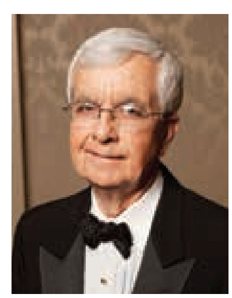
Thomas C. Smith '34
Albert J. Kurtzon '38
James L. McConachie '40
William J. Chambers Jr. '43
Marwin T. Doherty '44
Roger A. Burt '45
David C. McClintock '47
John S. Rode '47
Robert L. Cowles Jr. '48
William G. Hayden '48
Irvin Moehling '49
Harry W. Neuert '49
John Pearson '49
Richard A. Hohfeler Jr. '50
William A. Moore '50
Thomas C. Paisley '50
George S. Bayer '52
William N. Guthrie '52
Robert H. Olandt '52
Thomas F. Powers '52
Arthur R. Erbach '53
Ramsay Nokay '55
Norbert T. Bold '58
Darrell M. Fugelberg '58
Martin N. Kite '59
Larry R. Fay '60
Douglas M. Anderson '61
Mehlin B. Smith '64
Jean Y. Togikawa '80
Kristopher-Woo Whang '82
Arnold Stux '92

McCormick alumni honored

Two McCormick alumni were honored at the annual Northwestern Alumni Association award banquet in March.

Gwynne Shotwell ('86, MS '88) received the Alumni Merit Award for high achievement in a profession or field. Shotwell is president of SpaceX, a space transport company that has developed two space launch vehicles—Falcon 1 and Falcon 9—and the Dragon spacecraft, which will deliver cargo to the International Space Station for NASA. In December 2010 SpaceX became the first private company to successfully launch, orbit, and recover a spacecraft.

Alumni Merit Awards are presented to alumni who have distinguished themselves in their particular professions or fields of endeavor in such a way as to reflect credit on their alma mater.



Edward Voboril ('65) received the Alumni Service Award for outstanding service to the University. For the past five years Voboril has served as the chair of the NUvention: Medical Innovation course, which teaches students from across Northwestern how to turn ideas for medical devices into businesses.

The Alumni Service Awards are given in recognition of loyal service rendered voluntarily to the University through the NAA, an affiliated group, or a particular school.

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This image shows a hollow, bird's-nest-shaped three-dimensional structure composed of asymmetrically self-assembled manganese oxide nanowires from the lab of Harold Kung, professor of chemical and biological engineering. Researchers in the lab prepared these structures as electrode materials for batteries and catalysts for electrochemical reactions. The narrow diameter and elongated shape improve electrochemical performance. Courtesy of Xin Zhao.

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