Northwestern University | Robert R. McCormick School of Engineering and Applied Science | 1909–2009

Explore
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100 Years


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100
Years

Greetings from McCormick

The opportunity to celebrate 100 years of "Excellence at All Levels" comes once in a lifetime. Welcome to this Centennial edition of *McCormick* magazine!

In this issue we not only present a brief history and timeline of the school to recap and celebrate our past accomplishments, but more importantly tell the story of the initiatives, curriculum, and student groups that are shaping our future. We highlight several research areas where McCormick faculty and students are leading the way: nanotechnology and materials, transportation, networks and complex systems, computer science, engineering and medicine, energy, and design, among others.

Throughout the past 100 years, problem solving has been a hallmark of engineering education at McCormick. The school now fosters a culture in which innovation is not only encouraged but expected. Our future depends on the artful balance of nurturing and growing our undergraduate and graduate programs, fostering interdisciplinary research, and providing service to our alumni and friends. We have positioned ourselves as a place where technical skills are deep but are accompanied by creativity and humanistic depth.

We are committed to training whole-brain individuals who can address the most pressing problems facing society today. In this issue we discuss the evolution of McCormick's distinctive culture of design, one that has differentiated our students for the past decade, and outline our new Personal Development Initiative, which supports our students' personal growth — including their future career planning.

I invite you to join us at the Centennial events scheduled across the country. These events will highlight McCormick's interdisciplinary culture; each one is held in conjunction with another dean from Northwestern: the Kellogg School of Management, the Weinberg College of Arts and Sciences, the Feinberg School of Medicine, and the Law School. I think you'll find these occasions will be a great way to learn about our latest programs and research while connecting with other alumni and friends. Strengthening our alumni network is one of our goals. Register and learn more at the Centennial web site, www.mccormick.northwestern.edu/100. The site also includes historical photos, facts, and videos.

As our Centennial logo indicates, we have excelled through a commitment to explore, create, and ultimately transform our world. This is a journey that intertwines faculty and students, one where it is difficult to draw hard boundaries between teaching and research, learning and doing. And this would have been impossible without the continuing support of alumni and friends.

Please join us in celebrating 100 years of excellence.

Julio M. Ottino, Dean | September 2009

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

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The Master of Product Development Program (design, page 38)

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McCormick celebrates its Centennial during the 2009–10 academic year, and we want you to join the celebration! Visit www.mccormick.northwestern.edu/100 to learn more about McCormick's history, see what's new at McCormick, and register for the following events:

Campus Centennial Celebration
Friday, October 2, 2009, 3:30–5:30 p.m.
Garrett Lawn (south of the Ford Motor Company Engineering Design Center), Evanston campus
Hosted by Dean Julio M. Ottino, McCormick School of Engineering and Applied Science

San Francisco
Wednesday, October 14, 2009, 6:30 p.m.
de Young Museum
Hosted by Dean Julio M. Ottino and Sunil Chopra, interim dean, Kellogg School of Management

Chicago
Centennial Gala
Friday, October 30, 2009, 7 p.m.
The Modern Wing at the Art Institute of Chicago
Hosted by Dean Julio M. Ottino; remarks by University President Morton Schapiro

Los Angeles
Wednesday, January 20, 2010
Hosted by Dean Julio M. Ottino and Larry Jameson, dean, Feinberg School of Medicine

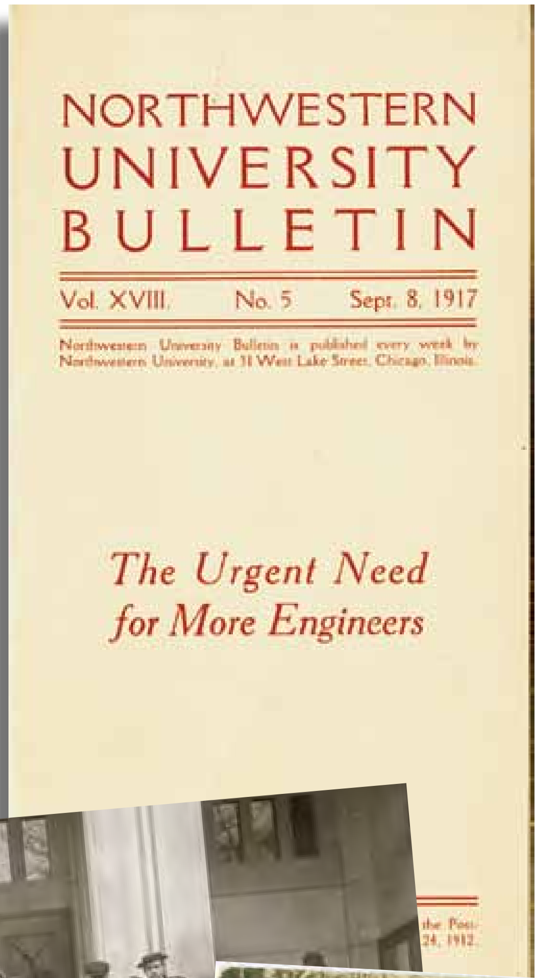
Washington, D.C.
Wednesday, April 28, 2010
Hosted by Dean Julio M. Ottino and David E. Van Zandt, dean, Northwestern University School of Law

New York
Thursday, May 13, 2010
Hosted by Dean Julio M. Ottino and Sarah Mangelsdorf, dean, Judd A. and Marjorie Weinberg College of Arts and Sciences

Register for these events at
www.mccormick.northwestern.edu/100

Engineering at Northwestern

Over the past 100 years, the Robert R. McCormick School of Engineering and Applied Science has grown and evolved from an idea to an innovative institution of education and research. Thanks to years of strong leadership and the support of entrepreneurial alumni and friends, the school now sits at the intersections of disciplines with an emphasis on problem framing and problem solving. While the past tells the story of the school's successes and challenges, the future holds the possibility of wherever students' and faculty analysis and creativity can take it.



NORTHWESTERN UNIVERSITY BULLETIN

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The Urgent Need for More Engineers

A culture for usefulness, 1873–1942

"In this age of railroads, and mining, and surveying, and navigation," the 1873 Northwestern course catalog stated, "the demand for trained, practical, and reliable engineers is far beyond the supply." Alas, the University was not yet able to meet that demand, as an economic downturn and lack of student interest led to dropping the few listed engineering-related courses. By the turn of the century, Northwestern's leadership saw the need for trained engineers, but establishing a proper school of engineering was slowed by several factors, not least of which was the perceived gulf between Northwestern's mission of "sanctified learning," in the words of its charter, and the calling suggested by the application of practical mechanics.

Several previous Northwestern presidents had failed to reconcile these philosophical differences by the time Abram Winegardner Harris was inaugurated in 1906. As he presented his plan for an engineering school to the trustees, he stressed that technical instruction would not replace, but rather be added to, "literary and ethical" learning and argued that engineering education was essential to the University's mission. The trustees were persuaded, and in 1909 the College of Engineering was established.

Engineering's newfound importance at Northwestern was reflected in the construction of a building to house the college: Swift Hall opened in 1909. The motto "Culture for Usefulness" was coined for the new college, which offered two tracks: civil engineering and mechanical-electrical engineering. The aim was to train future engineers for "the greatest average effectiveness in a lifetime, rather than for the … first years after graduation," as the school's literature put it. The curriculum favored strong

Top Northwestern University Bulletin, 1917
Above Members of a Northwestern engineering society, 1914
Immediate right Swift Hall, opened in 1909, was the original home of the engineering school.
Top right, opposite Walter P. Murphy

1909–2009

training in science and mathematics — an emphasis that came, some claimed, at the expense of applied engineering courses. What began as a mild bias toward theoretical learning grew over the next decades into a stark imbalance, with the school evidently producing too many engineers with too few hands-on skills. For this reason, in 1937 the Engineering Council for Professional Development withdrew its accreditation.

The crisis made plain the need for a more practical approach to engineering — one that prepared engineers for careers in industry. It fell to Walter Dill Scott, Northwestern's president from 1920 to 1939, to address the problem. In 1936 Scott received a mysterious letter stating that an unnamed donor wished to endow a major engineering institute in Chicago. The letter asked what plans Northwestern might have for such a program. Scott and his staff quickly determined that the potential donor was Walter Patton Murphy, an inventor and industrialist who had made his fortune in the railroad-supply line. Within a few months, Northwestern presented Murphy with a fully detailed plan for a new school of engineering, including an extensive cooperative program that allowed students to spend significant time in actual industrial jobs. Murphy was convinced that this was the most useful program possible and that Northwestern was the best university to undertake it. By 1938 it was settled. The new Northwestern School of Engineering would take its place as "second to none" among such schools, according to covenants between Northwestern and Murphy. The donor funded the enterprise with an initial gift of nearly $7 million, followed by a bequest of $28 million when he died in 1942.

This ambitious program demanded a new home. The Technological Institute — or Tech, as the new structure was called — featured a floor plan of tightly interconnected wings (resembling a pair of inverted Es) with long corridors, each devoted to a different department (including physics and chemistry, which found homes within the building). This arrangement reflected the current understanding of engineering and the sciences as a collection of discrete disciplines. Yet the manner in which the various hallways flowed into one another tacitly enabled cooperation and collaboration between departments. The Technological Institute was custom-designed for a period when technology was in transition.

Tech was completed in 1942 — just in time for the school and the University at large to feel the impact of World War II. The halls were instantly filled with men in uniform; the Navy Radio School occupied the fourth floor, while an officer training program occupied most other classrooms. Ovid Eshbach, the first dean of the new School of Engineering, overcame the uncertainty and turmoil of the period with characteristic calm. Eshbach is remembered for his unstinting goodwill in giving the military everything it needed. At the same time, he provided the reduced number of engineering students with the personal attention that was his trademark. Eshbach believed that the most important mission of the School of Engineering was preparation of students for useful careers; he also believed this work could be done very well at the undergraduate level. Thus Eshbach nurtured the co-op program and forged relations with industries all over the country.

Pioneers in research, 1942–85

Connection to industry became an issue for Donald Loughridge, a nuclear physicist who succeeded Eshbach as dean of the engineering school in 1953. Loughridge distrusted commercial ties, wanted them curtailed, and drew a figurative line in the sand — in part over the groundbreaking research of Robert Beam in microwaves, which had applications in and funding from industry. The resulting flap was as rancorous as anything in the history of the school and ended with Loughridge's resignation in 1955. This conflict reinforced the need to steer a course that respected both pure theoretical research and the freedom of faculty to forge relationships with private industry.

In the postwar period J. Roscoe Miller, University president from 1949 to 1970, made a series of bold moves to expand and improve Northwestern through modern facilities and first-class research. He had important allies on the faculty, among them metallurgist Don Whitmore, who had arrived at Northwestern in 1948. Working from his base in chemical engineering, Whitmore developed course work in metallurgy and in 1953 formalized a new graduate department in that discipline. In 1954 Whitmore convinced a former colleague at the University of Minnesota, Morris Fine, to move to Northwestern. Fine came with a range of experiences that included work on the Manhattan Project in Chicago and Los Alamos and with Bell Labs in New Jersey. Fine was named chair of the new graduate department of metallurgy. Within a short period, new faculty members were appointed and the department broadened its mission to include ceramics, polymers, and electronic materials. This new profile inspired a new name, the Department of Materials Science — the first such department in the world.

Its reputation in materials science now established, Northwestern received funding from the U.S. government in 1960 to create a center (one of three such sites in the nation) to promote interdisciplinary research. The result was the Materials Research Center. Distinguished faculty such as Jerome B. Cohen, an expert in X-ray diffraction, Johannes Weertman, whose field was dislocation theory, and his wife, Julia Weertman, an expert in the mechanical behavior of advanced materials, made important contributions to the center's creation. New equipment in the center — such as an electron microscope — attracted researchers from departments throughout the University and helped make the center a focus for collaborative research.

Paralleling advances in the materials sciences were efforts in biomedical engineering. Richard W. Jones broadened the context of engineering into the life sciences in the late 1950s, when he invited engineers to join him as he adapted engineering techniques to study human physiology. Among Jones's young colleagues was Christina Enroth-Cugell. Joining Jones's "systems physiology lab," Enroth-Cugell embarked on research using mathematical models to study the transmission of eye-to-brain signals. She developed and taught the School of Engineering's first physiology course, which featured the use of quantitative methods and mathematical analyses in the study of organ and cell function.


N. U. Tech Graduates First Woman Engineer

The early 1980s was a time of interdisciplinary work. The Catalysis Center, established in 1981 under John Butt, was one of the first important interdisciplinary centers in the University. The Center for Concrete and Geomaterials was created in 1981 under Zdeněk Bažant and eventually led to the hiring of Surendra Shah. Jan Achenbach's Center for Quality Engineering and Failure Prevention, Steve Davis's Center for Multiphase Fluid Flow and Transport, and Gil Krulee's Laboratory for Artificial Intelligence were all established in 1983.

Far left Ovid Eshbach, the first dean of the new School of Engineering, and students
Top left The Technological Institute under construction, October 1940
Left More than 2,000 people braved the near-zero weather to watch the fire during the construction of Tech in late 1940
Right Materials science equipment in the 1960s
Far right Electrical engineering equipment in the 1950s

Reengineering the school, 1985–95

"May you live in interesting times." Jerome B. Cohen, dean of the engineering school from 1988 to 1999, quoted that Chinese proverb in a letter to students and faculty in 1991 in reference to a sharp increase in enrollment, but it could have been a motto for his tenure as dean.

Cohen envisioned a future in which engineers would play central roles in solving global problems in such areas as energy, communications, and medicine. To that end Cohen took a series of bold and far-reaching steps. One of the first was to update Tech. By the 1980s the building showed its age. In a series of meetings in 1988 and 1989, Cohen and University President Arnold Weber discussed major gifts with national foundations. One prospect, the Robert R. McCormick Foundation, was interested in extending its reach into technology education. Foundation officials reviewed Cohen's plans and agreed with many points, including improved undergraduate teaching and increased attention to biomedical and industrial engineering. They also agreed that a revamped engineering program called for an extensively renovated building. The result was a 1989 grant of $30 million and a new name for the school: the Robert R. McCormick School of Engineering and Applied Science.

In addition to directing a complete rehab of Tech, Cohen oversaw the first major curricular revisions in a generation. There was some urgency behind the changes. Enrollments had been stagnant throughout the 1980s, and administrators charted a dismaying trend: first-year students were often disillusioned with their course work. Faculty discussed the problem, and most agreed that the standard freshman engineering curriculum — devoted largely to math and science courses that were not even taught by McCormick faculty — was a source of the trouble. To many students, these courses seemed disconnected from the larger McCormick experience.

In 1994 Cohen asked Professor Ted Belytschko to lead a committee to revise the first-year curriculum — to "take back the freshman year," as they put it. This was an opportunity to craft an engineering curriculum that anticipated the needs of the 21st century. After a year of weekly meetings and discussions with colleagues throughout McCormick and other schools, wide-ranging research, and some soul-searching, the committee proposed a radically new program, for which Stephen Carr, associate dean for undergraduate engineering, coined the name Engineering First®.

The new curriculum — a revolutionary approach to introducing freshmen to engineering — consisted of two sequences: Engineering Design and Communications (EDC) and Engineering Analysis (EA). The two-quarter EDC sequence challenged students with design projects from real clients: individuals, local businesses, faculty members, and organizations (eventually including the Rehabilitation Institute of Chicago). It also included writing modules and addressed the human element of engineering. EA streamlined the usual sequence of required engineering and science courses into a multidomain introduction to physics, mathematics, and computing and provided freshmen with tools to attack the engineering problems they faced in EDC.

In 1997 McCormick taught a prototype of the two-course sequences to a randomly selected group of 40 freshmen. By prototyping and testing the new curriculum — by acting like engineers — Cohen and his colleagues went a long way toward ensuring the success of Engineering First. In 1998 the EDC and EA sequences were adopted for all entering freshmen.

The success of Engineering First inspired graduate degrees in such areas as product development and design and innovation. These programs reflected the intensely interdisciplinary character of McCormick and stamped it as a place that could, and would, engage the needs of business and society. McCormick administrators sought to tailor the faculty to these goals, sometimes seeking out professors with non-academic backgrounds. One example was William White. One of Northwestern's first graduates in industrial engineering in 1961, White had retired as CEO of Bell and Howell Corporation in 1997. His store of real-world experience appealed to Dean Cohen, who added White to the industrial engineering faculty in 1998. Cohen then asked White to create an undergraduate "business basics" certificate at McCormick. The result (now known as the Business Enterprise Program) was a success, and it created demand for related courses such as Engineering and Entrepreneurship.

Another faculty member with a background in the business world was David Kelso, a Northwestern graduate who had worked for Abbott Labs and Baxter Healthcare. Kelso joined the biomedical engineering department in 1992 and taught a course in which seniors designed and built medical devices. Enthusiasm for the course and its results led Kelso toward what he found was all too rare in business: simple, economical, "sustainable" biotechnology solutions. Learning that he shared this objective with the Bill & Melinda Gates Foundation, Kelso and his colleagues sought funding. In 2006 they received a Gates grant and assembled other interested parties within Northwestern to establish the Center for Innovation in Global Health Technologies, which focused on the needs of resource-poor countries. In 2009 the center announced the development of a $1 diagnostic kit for AIDS.

An interdisciplinary era, 1995–2004

Henry S. Bienen, who assumed the presidency of Northwestern in 1995, understood the University's interdisciplinary character but also saw that the intersections between its schools and departments held many untapped possibilities. Bienen's interventions in this respect led to an unprecedented number of interdepartmental and University-wide initiatives.

McCormick had long been involved in notable interdisciplinary efforts on campus, including one of the earliest: the Transportation Center, founded in 1954. In 1970 Joseph Schofer joined the center, bringing a range of new ideas to the field. His interest in public policy marked him as a far-from-typical civil engineer, but his unquestionable quantitative skills helped him make social and political variables a part of transportation planning and operations. The interdisciplinary approach of engineers like Schofer became crucial to the Transportation Center as the interstate highway system grew and public investment in urban transit expanded. Schofer described his position, and that of the center as whole, as "the interface of how people interact with a technological system."

Ties between the Transportation Center and McCormick continued to grow, as in the close collaboration between the center and McCormick's Center for Quality Engineering and Failure Prevention. Created in the 1980s by Jan Achenbach, the center pioneered techniques of quantitative nondestructive evaluation to assess the integrity of metals and composite materials in commercial airliners and military aircraft. So strong were the ties between the school and the Transportation Center that the latter was folded into McCormick in 2005.

A particularly prescient initiative in interdisciplinarity came in 1990 with the advent of a master in management and manufacturing (MMM) degree, offered jointly by McCormick and the Kellogg School of Management. As the MMM degree (combining the MBA and the MEM degrees) grew in popularity, it evolved to address a wide range of business topics, such as change in the global economy and American entrepreneurship.

Early in his administration, President Bienen was presented with a vision of the future by Chad Mirkin and colleagues from McCormick. Science and engineering were on the verge of massive breakthroughs, they explained, all linked to the emerging field of nanotechnology. Involving the manipulation of matter on a molecular level, nanotechnology required the analytical skills of pure science and the inventiveness of engineering. Many saw this field as a path to a whole new class of innovations in medicine, electronics, and other areas — innovations that would transform both science and business. Mirkin and his colleagues presented ambitious plans, notably a major proposed nanotechnology facility. As a result, nanotechnology became one of the main research triumphs of the Bienen administration. With an entrepreneurial spirit, Bienen developed an array of nanotechnology initiatives, many of which he oversaw personally.

Bienen's efforts included the recruitment of top faculty — in particular Sam Stupp, a Northwestern PhD graduate and longtime leader in the field of self-assembly and biomaterials. Stupp's nanoscale work had touched on the immense potential of regenerative medicine, and he had made significant progress in manipulating molecules so that they might "self-assemble" into functional materials.

Top left An express keypunch, 1977
Middle left A Tech open house, 1980s
Left Tech plaza, 1970s
Above Professor Linda Broadbelt with a student, 1998

With remarkable tenacity, Bienen convinced Stupp that he should come to Northwestern. "There was this ambition to create new things, particularly in interdisciplinary fields," says Stupp. "Henry Bienen was determined to make the right investments and promote interdisciplinary activity wherever he detected it."

Nanotechnology stood at the nexus of many opportunities, including the commercial application of research efforts. Among those who staked out this territory was Mark Hersam, who arrived at McCormick in 2000. One of his interests was carbon nanotubes, a specialty that put Hersam in a position to develop better-performing nanoelectronic materials for the microelectronics industry. He had found a way to sort nanotubes of consistent size and shape, thus overcoming a significant barrier to their widespread utility.

At the turn of the new century, research goals were changing, benchmarks were shifting, and money was limited. At McCormick the question was how to follow up on the improvements initiated by Cohen, who retired in 1998. His successor, John R. Birge, wrote an apt assessment of the school's prospects for the 21st century: "Technologies fall into three main areas: cross-sectoral technologies that cut across multiple industrial sectors, interstitial technologies that lie on the borders between disciplines and industries, and societal technologies that have broad impact on global society." The message, in other words, was that true innovation was essential and would be found at the edge of traditional disciplines.

The school's commitment to innovation — as well its affinity with industry — was affirmed by a $10 million gift in 2001 from the Ford Motor Company for a new engineering design center. The resulting building, completed in 2005, provided a physical center for the type of visionary engineering education that had its roots in Engineering First. (The case was made to Ford that the new center would encourage the sort of design thinking Detroit needed.) The establishment of the building provided McCormick with a catalyst for the interdisciplinarity and innovation needed for real change.

Excellence at all levels, 2004–09

Among younger faculty members who flourished in this creative, entrepreneurial environment was Julio M. Ottino, who joined the faculty in 1991. Born in Argentina to a scientist father and artistic mother, Ottino acquired talent in both areas but chose chemical engineering as his profession, partly because it made use of his talent for mathematics. He continued to paint with enough conviction that his biggest early scientific breakthrough came from an insight that struck him while working on a canvas: he discerned that the mixing of fluids could be understood in geometric terms and through a branch of mathematics that came to be called chaos theory.

At Northwestern, Ottino pursued his interest in chaos theory and was eager to discuss it with others. The subject attracted

a motivated group of faculty members from around the University, and soon a permanent organization with University support took shape. The Northwestern Institute on Complex Systems (NICO), originally codirected by Ottino and Daniel Diermeier of Kellogg, embraced a wide range of questions and researchers, many from McCormick, for cutting-edge collaborative research.

In 2004, not long after NICO was founded, Birge left Northwestern and the search for a new McCormick dean was launched. Ultimately the committee concluded that the best person to address the almost unimaginably complex set of issues facing the school was its own specialist in chaos theory, and Ottino became dean of the McCormick School in 2005.

Ottino believed the greatest opportunities for McCormick were to be found in enhancing design thinking. An emphasis on the creative side of engineering had distinguished Northwestern from schools that focused exclusively on "left-brain" or analytical skills. Ottino was convinced that engineering at its very best required both ingenuity and analysis. As a result, several new programs implementing design thinking were implemented throughout the curriculum.

New initiatives drive change

The Institute for Design Engineering and Applications was created in 2002, offering courses that ranged from training in computer-aided design systems to topics in human-centered design to the emerging field blending technology with social science; the institute also offered an undergraduate major in manufacturing and design engineering.

McCormick's new center for design, the Ford Motor Company Engineering Design Center, was dedicated in 2005. Speaking at the ceremony was University trustee Gordon Segal, who reiterated the importance of design in all aspects of society — citing his own business, the Crate & Barrel retail empire, which he founded with his wife, Carole. "Design brings ideas to life," Segal said. After the dedication, Ottino and the Segals continued to discuss this theme. As the Segals witnessed the swift evolution of design thinking at McCormick, within a few months they had conceived the Segal Design Institute. Dedicated to the study of human-centered design, it would take the place and continue the work of the Institute for Design Engineering and Applications, and it crystallized the larger message of McCormick: the future of the society depended upon technology, creativity, and well-designed solutions.

With the establishment of the Segal Design Institute, Ottino asked Professor Ed Colgate to devise a design curriculum for graduate students. Colgate enlisted the collaboration of Don Norman, whose academic career was intertwined with his work in private industry and his writing of influential books such as *The Design of Everyday Things,* in which he explained his ideas about the profound importance of design. Norman had joined the McCormick faculty in 2001 in part to foster design thinking in engineers and to encourage design-driven organizations. Colgate and Norman developed the Master of Engineering in Design and Innovation Program, which accepted its first students in 2006.

The drive to find real-world applications for research in many ways defines McCormick in the 21st century. Take, for example, the issues surrounding energy and sustainability — issues that involve scientific research, geopolitics, public policy, transportation, and more. A major research university might be the only place where such vexing problems can be effectively attacked. This was the impetus behind the 2008 creation of the Initiative for Sustainability and Energy at Northwestern (ISEN), a program to coordinate and promote all activities related to energy and sustainability at the University with the goal of harnessing its interdisciplinary power to solve pressing problems. Ottino was an early advocate of the organization, and one of its directors, David Dunand, came to energy studies through materials science, where his work in lightweight alloys and foams led naturally to visions of a more energy-efficient future. "ISEN is a very good example of how wide collaboration can contribute, and is actually essential, to solutions to real crises," Dunand said.

The marketplace is perhaps the most effective avenue for bringing the latest engineering thinking to bear on real-world problems. McCormick acknowledged this in 2008 with the creation of the Farley Center for Entrepreneurship and Innovation. The center was launched by a gift from James and Nancy Farley. A 1950 graduate in chemical engineering, James Farley worked for General Electric, moved into a job as a salesman of motor controls, and built expertise in the field before launching his own successful manufacturing company. "We built our company from a dry start," he said. Observing McCormick's evolution with interest, Farley believed that entrepreneurship could be taught, and soon the Farley Center was born. Its first course was NUvention: Medical Innovation, which demanded dialogue between engineering students and those studying law, medicine, and management.

Top **Students in the prototype shop in the Ford Motor Company Engineering Design Center**
Right **The dedication ceremony of the Ford Motor Company Engineering Design Center and views of the building**

The ultimate lesson of the course was to negotiate the barriers that separate neat theories from creative solutions.

Engineering leadership

"We cannot ignore the key qualitative differential that has led to our past success: creativity," Ottino wrote in an op-ed piece in 2006 in the *Chicago Sun-Times.* He was speaking of the United States, but his words apply as well to Northwestern's engineering program over the past 100 years. Under varying and increasingly complex conditions, a series of McCormick deans have emphasized that technical knowledge was not enough. Engineers need, wrote Ottino, to "create, rather than simply absorb, knowledge" — and that is what McCormick has endeavored to do.

"McCormick has made major investments in the last few years, and they have paid off extremely well," said President Bienen prior to his retirement in 2009. "Northwestern now looks to McCormick for creative leadership in many new fields." That leadership can be measured by the school's prominence in University-wide centers and research institutes and by the large number of joint appointments between McCormick and other Northwestern schools. Perhaps most importantly, these efforts leverage advances in knowledge and further the school's commitment to a holistic concept of engineering. Laboratories all over McCormick and engineers elsewhere in the University address social, economic, and even political questions with enthusiasm as they work to advance the deep well of technical knowledge available to them.

McCormick's strength has never been more important than it is in 2009, as the financial crisis shakes confidence around the world and as the University experiences a presidential transition. Daniel Linzer, Northwestern's provost since 2007, saw the school's true character in the midst of these changes. "The school has undergone a remarkable transformation over the last few years, thanks to outstanding leadership, a very strong faculty, excellent staff support, and enthusiastic and highly motivated students," he said. "McCormick has a clear sense of what it is and where it wants to go." That sentiment was echoed by the University's new president, Morton Schapiro. "I have been on campus for only a short time," he said, "but I was immediately impressed to see how tightly integrated McCormick is within the fabric of Northwestern."

That sense of identity and direction is driven by the belief that engineers and the McCormick School of Engineering and Applied Science are on the front lines of future innovation. "Engineering used to be defined by what we manufactured," says Ottino. "Now more than ever we have to be defined by how we think."

—Jay Pridmore; edited by Emily Ayshford

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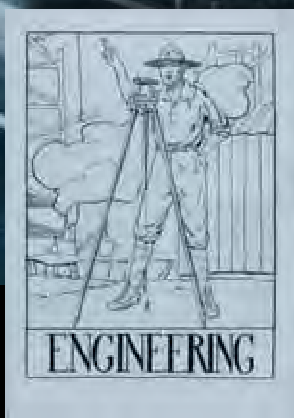


1909 The College of Engineering is established and offers two tracks: civil engineering and mechanical-electrical engineering. Swift Hall of Engineering is completed.

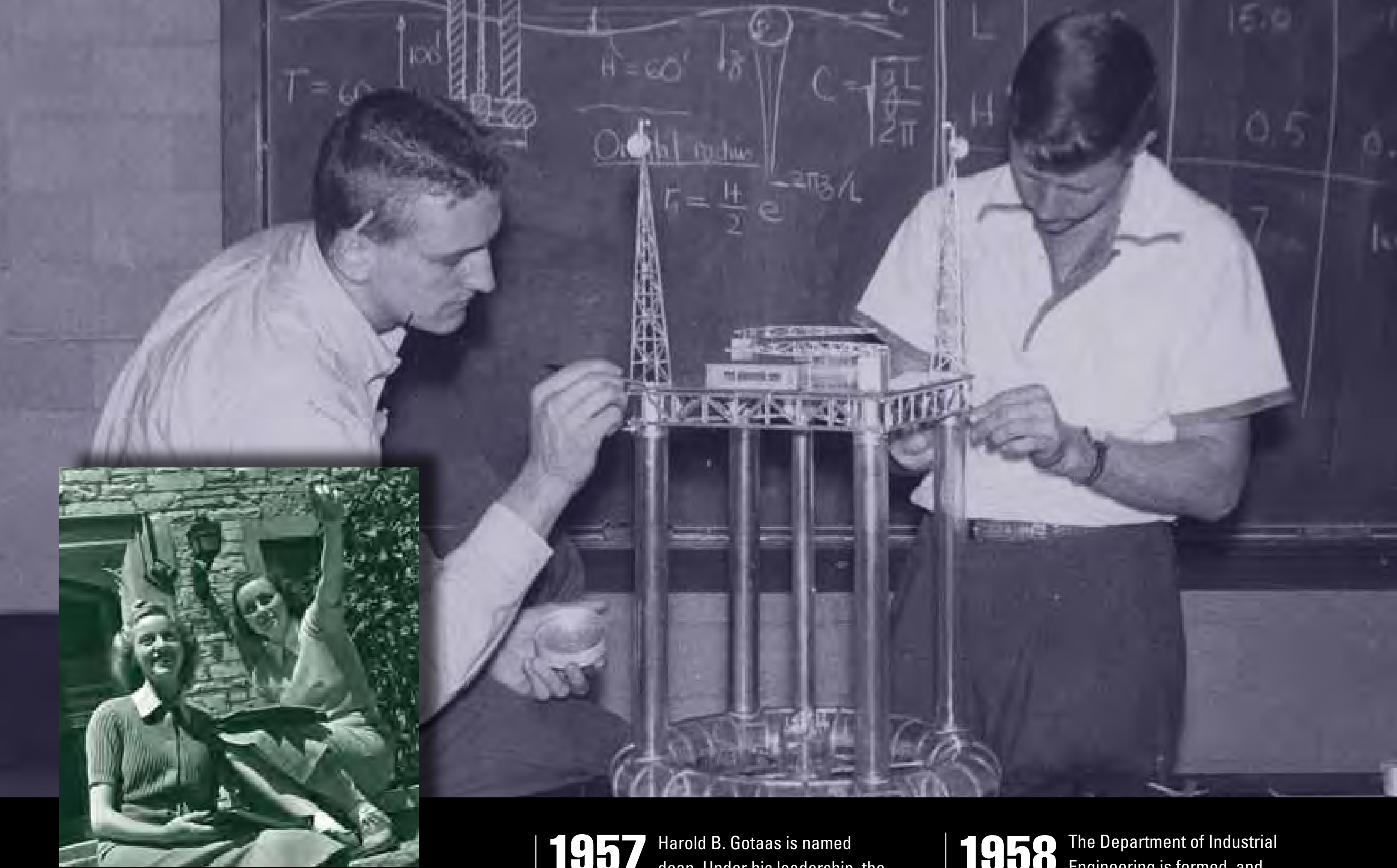
1926 The BS degrees in engineering, mechanical engineering, and industrial engineering are established.

1929 The college boasts an enrollment of 305, similar to the other premier engineering schools in the country.

1939 Ovid W. Eshbach is named dean. A grant of $6.7 million from the Walter P. Murphy Foundation establishes the Technological Institute. The undergraduate chemical engineering program is established.

1941 The first students begin assignments in the Walter P. Murphy Cooperative Engineering Education Program. Construction of Tech is completed.

1942 Walter P. Murphy wills nearly $28 million to endow engineering and the sciences at Northwestern.



1953 Donald Loughridge, a physicist who worked on the Manhattan Project, is named dean.

1957 Harold B. Gotaas is named dean. Under his leadership, the school continues to develop graduate research programs to complement the undergraduate curriculum.

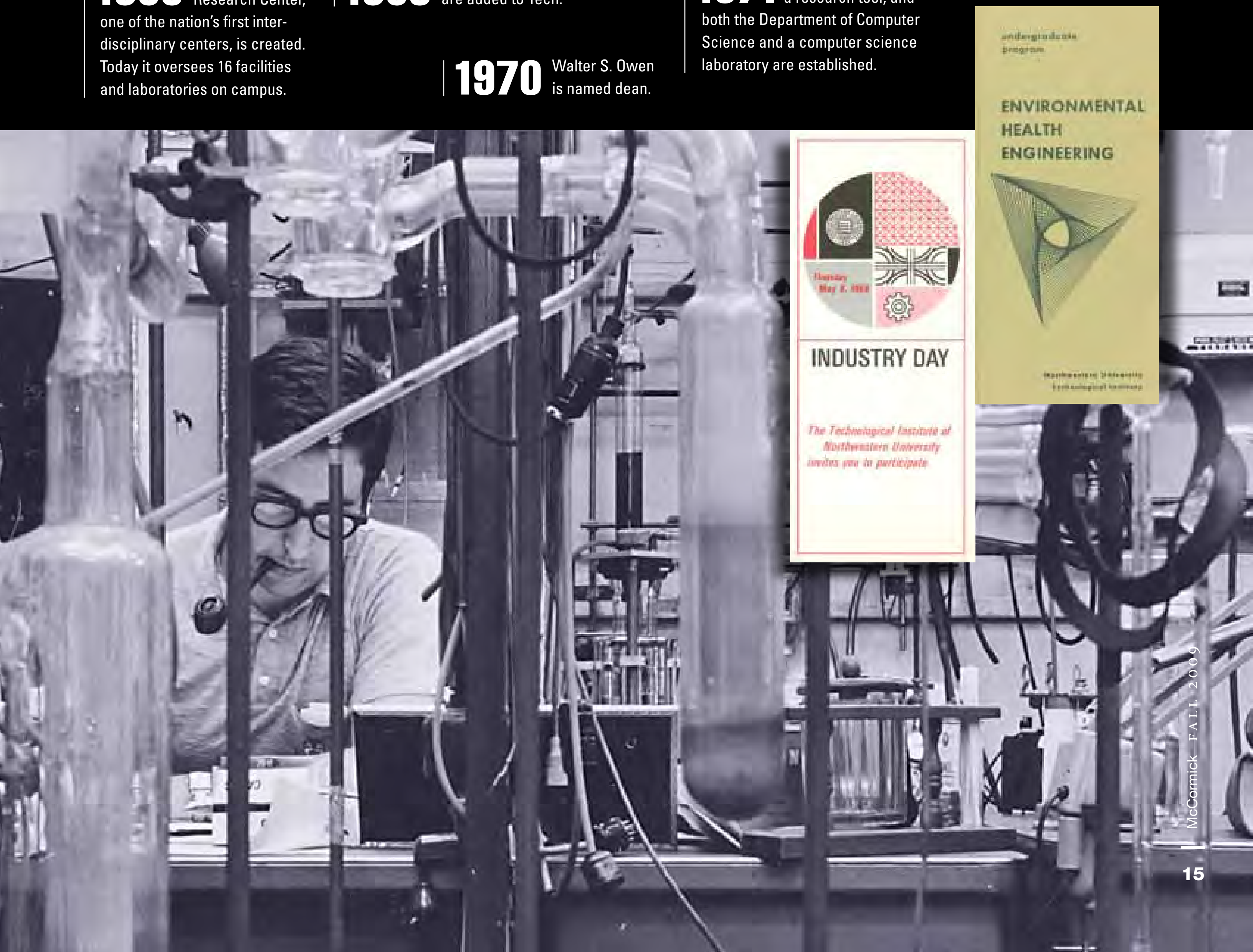
1958 The Department of Industrial Engineering is formed, and the Department of Metallurgy becomes the Department of Materials Science — the first such program in the world.

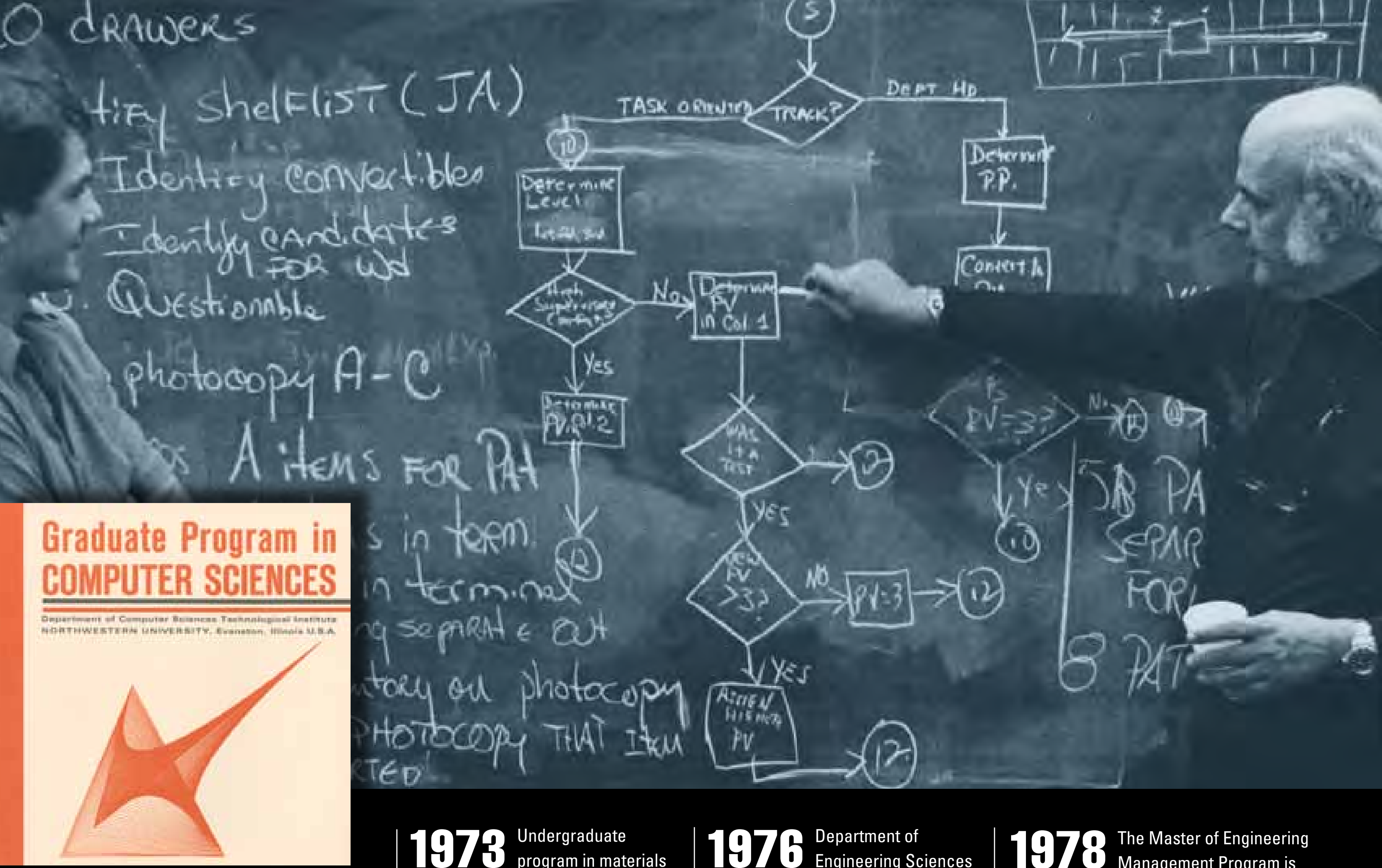
1960 The Materials Research Center, one of the nation's first inter-disciplinary centers, is created. Today it oversees 16 facilities and laboratories on campus.

1963 Two new wings are added to Tech.

1970 Walter S. Owen is named dean.

1971 Computers grow as a research tool, and both the Department of Computer Science and a computer science laboratory are established.



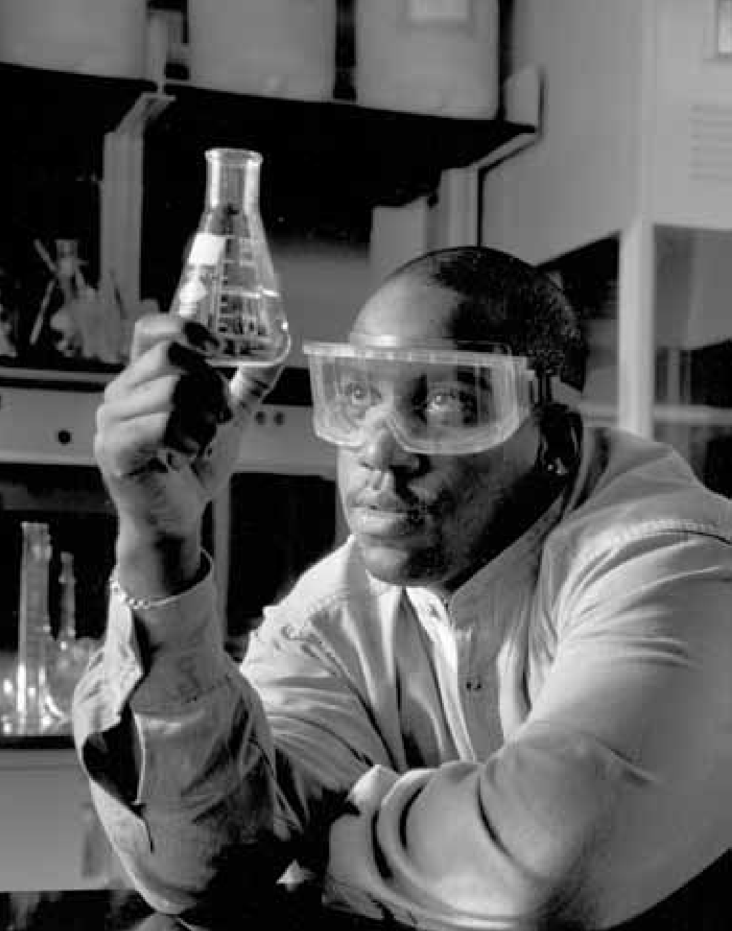


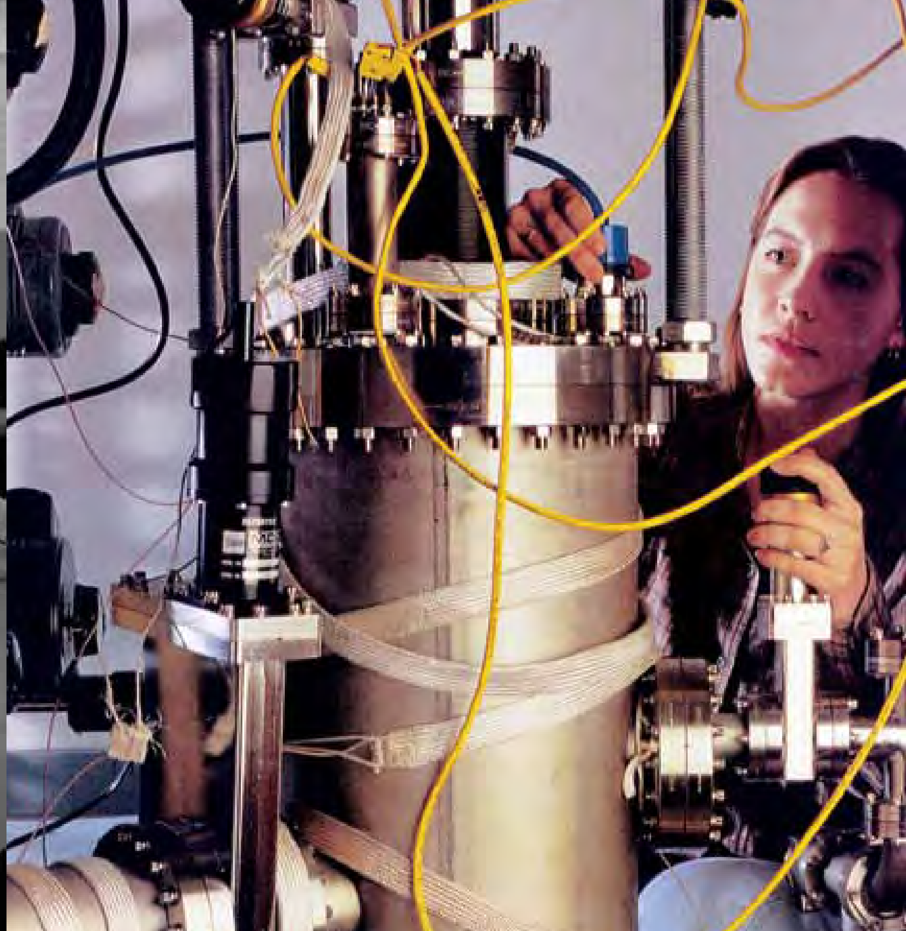
1972 Interdisciplinary undergraduate program in biomedical engineering begins.

1973 Undergraduate program in materials science and engineering begins. Bruno Boley is named dean.

1976 Department of Engineering Sciences becomes the Department of Engineering Sciences and Applied Mathematics.

1978 The Master of Engineering Management Program is founded. McCormick now offers seven professional programs.

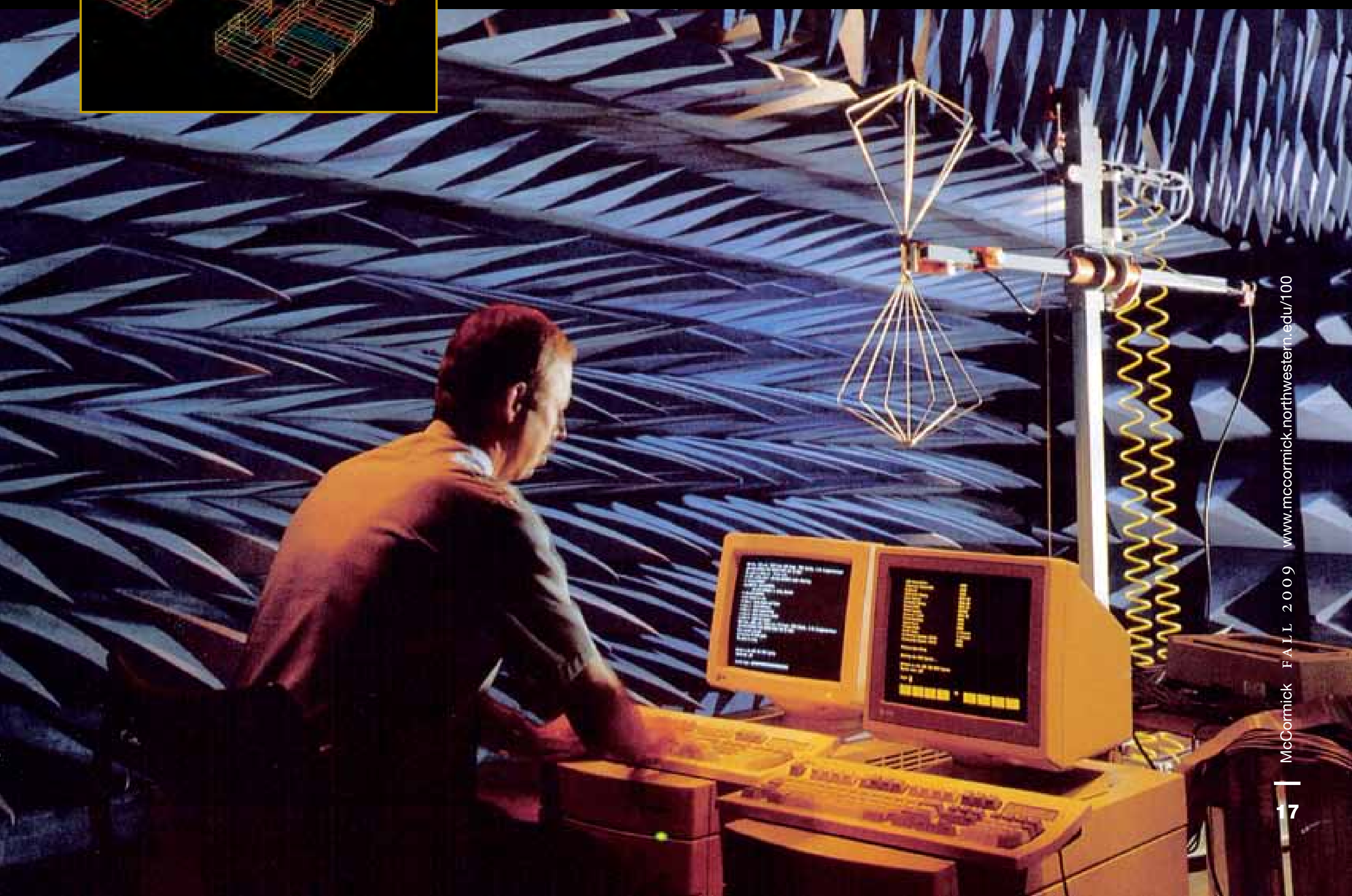




1986 Jerome B. Cohen is named dean. He oversees major curricular changes and the renovation of Tech.

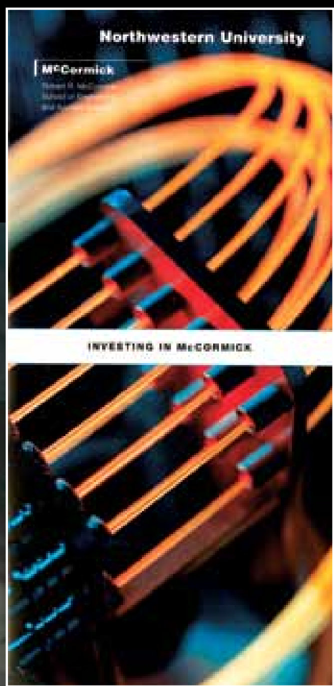
1989 The school is renamed the Robert R. McCormick School of Engineering and Applied Science after receiving a $30 million grant from the Robert R. McCormick Foundation.

1990 The MMM program is created, allowing students to earn both an MEM degree and an MBA from Kellogg.



1997 The Engineering First program is phased in for undergraduate students.

1999 John R. Birge is named dean. Interdisciplinary research is encouraged.



2005 Julio M. Ottino is named dean. The Ford Motor Company Engineering Design Center is completed, providing a home for design activities at McCormick.

2007 The Segal Design Institute is founded, named in honor of a gift from Crate & Barrel cofounders Gordon and Carole Segal.

2008 The Farley Center for Entrepreneurship and Innovation is created after being endowed by a gift from the James N. and Nancy J. Farley Foundation. The Initiative for Sustainability and Energy at Northwestern is formed. An undergraduate program in architectural engineering and design is established.

2009 McCormick celebrates 100 years of engineering excellence.

"McCormick allows you to be an engineer but it also allows you to experience other things that might be of interest to you — passions that exist outside of engineering that you could integrate into your engineering curriculum."

Shruti Mehta '03
Process improvement leader,
Northwestern Memorial Hospital

"McCormick has given me critical thinking, it has given me a sense of responsibility, it has taught me how to be creative and deal with time management."

Earle LeMasters '08
Ensign in the U.S. Navy

"There are more engineering undergraduates as CEOs of Fortune 500 companies than there are business majors, and I believe it's because of those analytical skills engineers get. I really feel that I got those at McCormick."

Greg Fraser '77, MS '78
President, Vapex Environmental Technologies Inc.

"I don't know many universities or certainly engineering schools where you can get that breadth of world-class teaching and world-class experience."

David Eckert '77
Chairman and CEO,
Allan, James & Co. Inc.

"Engineering really opens doors to so many career opportunities. People seek the way we quantify things, the way we solve problems."

Georgia Borovilos '02
Civil engineer, City of Chicago

"What engineering fundamentally prepares one to do is efficiently and effectively solve problems."

Ava Youngblood '79
President and CEO, Youngblood Executive Search Inc.

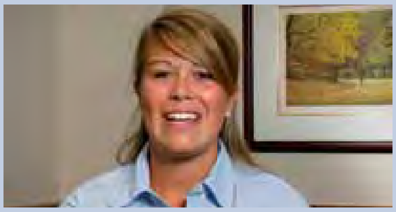
"You learn a way of thinking that transcends cultures — that can be applied to any culture."

Marc Lim '08
Medical student at the Feinberg School of Medicine, Northwestern University

"Engineering is a great degree choice because it promotes a way of thinking. It helps you develop your analytics and forces you to challenge yourself."

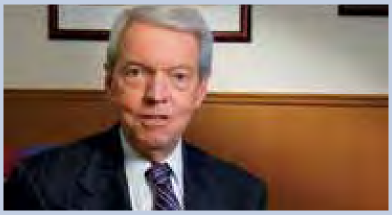
Laurie Dominijanni '08
Industrial engineering management trainee, UPS

"I have personally gotten to know many of the faculty and administration in my time here. The faculty are very accessible and willing to support you and help you."



Jessie Donato '08
Medical student at Case Western Reserve University

"Support for the education for our undergraduates and graduates is, I think, second to none at this point."



William White '61
Professor of industrial engineering and management sciences;
former CEO, Bell & Howell

RESEARCH FOR

Notice something different about these images?
See page 39 for an explanation
of this innovative imaging process.

Research at McCormick today crosses disciplines and defies boundaries in pursuit of solutions to the world's most pressing problems. What began as an engineering school with two tracks — civil engineering and mechanical-electrical engineering — has flourished and grown into a world-class research institution with eight engineering departments, 180 professors, and a host of research programs whose results affect millions of people around the world. It's engineering in the best sense of the word: entrepreneurial and cross-disciplinary. In the following pages you'll find a sampling of the types of research conducted at McCormick that are making an impact today. By Emily Ayshford.

THE FUTURE

ENGINEERING AND MEDICINE

Just 100 years ago, a simple infection could have spelled doom for an otherwise healthy patient. But over the past century, the rate of discovery in medicine and technology has exploded exponentially, as scientists and engineers have found new cures and diagnostics for society's greatest medical challenges.

Yet as we move through the 21st century, scientists and engineers realize that the future of medicine will be found in new ways of thinking, such as searching the nanoarchitecture of cells for evidence of cancer or growing egg follicles outside the womb or using nanodiamonds to deliver drugs and citric acid to develop ligaments. Breakthroughs at this level require researchers who understand not only science but also the application of that science to medical problems. Faculty members at McCormick bridge this gap from concept to application, and several are tackling the mammoth problem of medicine: cancer.

Consider **Vadim Backman,** professor of biomedical engineering, whose goal is to develop screening tools that would allow patients to be easily screened for major types of cancer in a visit to their primary care physician. Backman and his team are creating a suite of tools that use optical technologies to analyze cells for the presence of cancer. They have shown that nanoscale changes in cells caused by cancer can be detected using optical techniques called partial-wave spectroscopy, low-coherence enhanced backscattering spectroscopy, and four-dimensional elastic light-scattering fingerprinting. These technologies make use of a biological phenomenon known as the "field effect," a hypothesis that suggests that cancer causes changes that can be detected throughout the organ and even in neighboring tissue.

With colon cancer, for example, Backman has shown how computer analysis of the way light shines, scatters, and bounces off tissue samples taken from the rectum can show the "fingerprint" of colon cancer in the nanoarchitecture of the cells. To detect pancreatic cancer — a cancer so notoriously difficult to detect that it has a five-year survival rate of just 5 percent — Backman has taken cells from the duodenum (part of the small intestine) and used this approach to accurately discriminate with 95 percent sensitivity between healthy patients and those with the disease.

Backman's group is now expanding these tools to test them on lung, ovarian, and esophageal cancers. None of this would be possible, he says, without collaboration across disciplines and between academia and the clinic. "Our program here at Northwestern is a truly collaborative, very integrative, translational program where you have an exchange of ideas between clinicians and engineers resulting in significant symmetries," he says.

Dean Ho, assistant professor of biomedical and mechanical engineering, and his research team are looking for new ways to treat cancer. Ho works with nanodiamonds — tiny diamonds that have a diameter of two to eight nanometers — in developing new drug delivery systems. For example, Ho has aggregated clusters of nanodiamonds and then loaded a chemotherapy drug on the surface. When in the body, the drug remains inactive until the cluster reaches its target, when the cluster breaks apart and slowly releases the drug. The clusters are ideal for carrying chemotherapy because they shield normal cells from the drug and prevent problems that plague current drug-delivery systems — such as inflammation, which can block the drug's effectiveness and even promote tumor growth. Ho has also used tiny chips coated with layers of nanoscale polymer films to build platforms that hold and slowly release the anti-inflammatory drug Dexamethasone. The films act like an invisibility cloak, hiding the chips from the body's defenses until it is ready to be released.

While Backman focuses on cancer screening and Ho works on treatment, **Lonnie Shea,** professor of chemical and biological engineering, and his collaborators help women who have survived cancer. Chemotherapy and radiation can leave female cancer survivors infertile, but Shea and Teresa Woodruff, Thomas J. Watkins Memorial Professor of Obstetrics and Gynecology at the Feinberg School of Medicine, have worked together to create an ex vivo (outside of the body) environment

Liu

in which a young follicle — an egg and the spherical group of specialized cells that surround it — can grow and mature to a stage at which the egg can be fertilized and implanted into the uterus. This technique could allow women to cryogenically preserve ovarian tissue containing follicles prior to cancer treatment, then use the tissue to obtain mature eggs when they are ready to start a family.

This collaboration in oncofertility brings together faculty from across disciplines who are focused on one goal. "Now we have teams of people that are thinking about how can we best manage fertility options for patients that were never considered before," Shea says.

In addition to studying cancer, faculty members are working to develop new materials inspired by nature. **Guillermo Ameer,** associate professor of biomedical engineering, uses citric acid as the base for new polyester biomaterials that could help the body accept medical implants, develop replacement ligaments for injuries, and deliver drugs within the body. **Phillip Messersmith,** professor of biomedical engineering, is creating bio-inspired materials to repair, replace, or augment human tissue. Messersmith has created a new kind of adhesive called geckel, which mimics and combines the adhesive properties of geckos and mussels and stays sticky underwater.

Other faculty members are working on new devices for health care. **Chang Liu,** professor of mechanical engineering and of electrical engineering and computer science, is developing new kinds of contact, flow, and touch sensors that may be useful in health-care settings: contact sensors could be used in catheters for minimally invasive surgery, flow sensors could be used in IV lines, and touch sensors are already used in robotic surgical tools to help increase efficiency and accuracy. "These sensors also alleviate the need to constantly monitor a patient, which will reduce health-care costs and give the patient more privacy and independence," Liu says.

David Kelso, professor of biomedical engineering, and his lab have created two low-cost HIV tests for use in developing countries by taking existing tests and modifying them to work in small, battery-operated devices (see *McCormick* magazine, spring 2009). Kelso, who directs the Center for Innovation in Global Health Technologies, leads student projects to create new kinds of diagnostic and treatment options for diseases in developing countries, like South Africa. Northwestern students have traveled there and brought digital X-ray systems to clinics, developed a tuberculosis tracking system, and created an apnea monitor for premature infants. "Projects like these take engineering out of the academic setting and give it a humanitarian goal," Kelso says.

Perhaps Lonnie Shea puts it best when he says providing life-changing diagnostics, treatments, and lifestyle options like these makes all the hard work worth it. "That's really what keeps us going," he says. ■

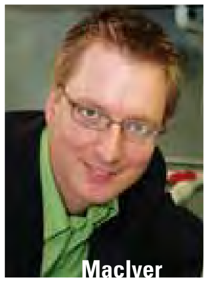
NEURAL ENGINEERING

For **Mitra Hartmann,** it's rat whiskers. For **Malcolm MacIver,** it's fish that release electric signals. But for both faculty members and their adjoining labs, it's the path to learning more about how our brains work. Hartmann, associate professor of mechanical engineering and biomedical engineering, and MacIver, assistant professor of mechanical engineering and biomedical engineering, work in the area of neural engineering, which seeks to apply basic knowledge of the nervous system to develop useful technology, and, conversely, to use engineering tools to better understand the nervous system.

Hartmann's research uses the rat whisker system as a model to understand how the brain seamlessly integrates the sense of touch with movement. Rats are nocturnal, burrowing animals that move their whiskers rhythmically to tactually explore the environment. The Hartmann lab has constructed robotic whisker arrays that can brush against an object to determine its three-dimensional shape. The group also uses high-speed video to examine the relationship between head and whisker movements and gain insight into the underlying organization of the nervous system.

Hartmann anticipates that cracking the problem of sensory-motor integration in the rat whisker system will yield general insights into how the nervous system functions. "We're interested in the principles that underlie mammalian brain structure and function and in how information is transformed at various stages in the nervous system," she says. "The rat whisker system is a wonderful model to look at these sorts of questions."

Hartmann

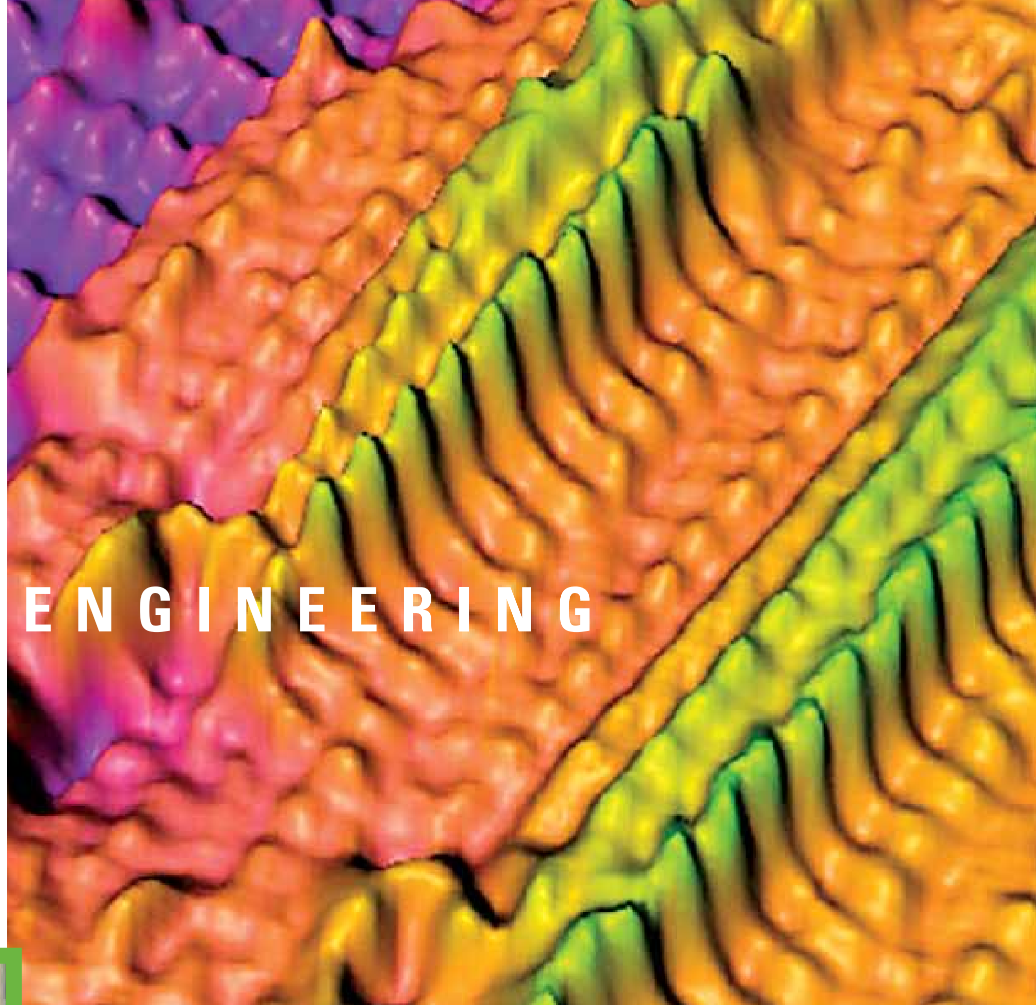


MacIver

MacIver studies how an animal's biomechanics and sensory function complement one another in agile adaptive behavior, using weakly electric fish as a model organism. These animals hunt at night in rivers of the Amazon basin using their electrical discharges as a kind of radar system. Because their signals only go out a short distance and in all directions, the fish have evolved remarkable agility to enable them to reach the objects they detect, including the ability to swim backward and vertically. Because their movement abilities are so closely intertwined with their sensory abilities, they are ideal subjects for uncovering principles of sensorimotor integration.

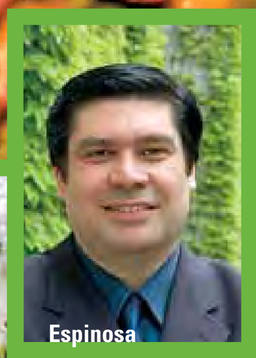
Fish brains aren't as complex as human brains but contain all the major components of human brains besides the neocortex. MacIver's research has led to new robotic sensory technology that uses weak electric fields and a robotic fish that uses the same unique style of swimming as his Amazonian subjects, which will help develop this research into a new underwater vehicle propulsion technology. ■

NANO ENGINEERING



Nanotechnology has been heralded as the science of the future: controlling matter at the atomic and molecular scale has huge implications for next-generation electronics and materials and for harnessing the potential of self-assembling molecules. Early on, Northwestern saw the big promise of working at such a tiny scale — a nanometer is one billionth of a meter — and positioned itself at the forefront of the field by hiring faculty and opening centers to foster research in nanotechnology. Now, as researchers continue to find new ways to explore and create at the nanoscale, we can begin to see the fruits of their labor.

Research at the nanoscale has broad implications in regenerative medicine, as evidenced by the research of **Sam Stupp,** Board of Trustees Professor of Materials Science and Engineering, Chemistry, and Medicine. Stupp directs the Institute for Bionanotechnology in Medicine, which combines the expertise of faculty members from across Northwestern to promote interdisciplinary research and education in biomedical science and engineering that will ultimately contribute to the development of highly advanced procedures in human medicine.



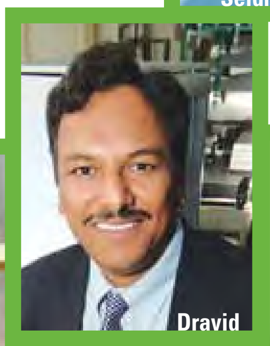
Stupp has developed materials that promote regeneration in the nervous system and could influence therapies for spinal cord injury and Parkinson's disease. He is a recognized leader in molecular self-assembly, the strategy used by biology to create highly ordered, defect-free structures. His strategies for developing nanostructured materials involve the synthesis of molecules programmed to self-assemble into functional materials with applications in fields ranging from electronics to regenerative medicine and cancer therapies. He has also developed new materials for the regeneration of bone and cartilage and founded the company Nanotope to translate his nanoscience discoveries to clinical use. In the area of electronics, his group recently published research on the creation of high-performance photoconducting materials using environmentally friendly zinc oxide that could allow electronics like cell phones, photovoltaics, and digital cameras to be more green and efficient.

Chad Mirkin, George B. Rathmann Professor of Chemistry, professor of biomedical engineering, chemical and biological engineering, materials science and engineering, and medicine, has created groundbreaking technologies for medical diagnostics and nanoscale fabrication. His low-cost, FDA-approved medical diagnostic system, Verigene IDTM, utilizes nanoparticle-based assays to test patients for several different diseases at the one time. "The test can be thousands of times more sensitive than any commercial system out there and has the power to revolutionize medical diagnostics," Mirkin says. He also developed dip-pen nanolithography, an ultra-high-resolution molecule-based printing technique that can be used to print features of proteins, DNA, and other biological materials on tiny surfaces, allowing researchers to study how viruses infect cells and to understand the differences between healthy and cancerous cells.

Mirkin is the director of the International Institute for Nanotechnology at Northwestern and has also helped found two companies to commercialize these technologies: Nanosphere and NanoInk.

Extending the properties of materials is a major goal of nanotechnology, especially in the field of carbon nanotubes. These tiny carbon molecules rolled up into cylinders have exceptional mechanical and electrical properties that could lead to new kinds of transistors, sensors, and other mechanical devices. **Bob Chang,** professor of materials science and engineering, developed a technique to grow large quantities of high-quality nanotubes and published the first paper on field emission flat-panel displays. **Mark Hersam,** professor of materials science and engineering and professor of chemistry, has used nanotubes to make thin, semi-transparent films that could lead to improved flat-panel displays and solar cells.


Seidman


Dravid


Lauhon


Grzybowski

Hersam has also worked with Stupp to find a way to overcome one of the obstacles to the large-scale use of nanotubes. Currently scientists cannot grow uniform carbon nanotubes, so they must be sorted by size (which defines their properties). Hersam has developed a sorting method called density gradient ultracentrifugation. "While carbon nanotubes have great potential," he says, "there is no large-scale technology based on them because of this sorting problem. We published a paper on the process, and the response was overwhelming. I stopped counting the number of requests for samples when it exceeded 100." Hersam has also founded a start-up company based on the technique.

Scientists at McCormick are working to gain a more complete understanding of one-dimensional nanostructures (nanotubes and nanowires) and their potential. **Horacio Espinosa,** James N. and Nancy J. Farley Professor of Mechanical Engineering, made the first experimental measurements of the mechanical properties of nanotubes that correspond to theoretical predictions. He has developed the world's first nanofountain probes, which are particularly useful in the nanomanufacturing of carbon nanotube-based devices as well as in single-cell delivery of drugs. He also pioneered architectures and models employed in carbon nanotube-based nanoelectromechanical systems, which can be used in next-generation electronics and sensors.

Lincoln Lauhon, associate professor of materials science and engineering, is exploring new techniques for visualizing structures at the nanoscale. He recently provided an atomic-level view of the composition of a semiconductor nanowire that will help engineers better predict the electronic properties of nanowire devices. "If we can understand the origin of the electrical properties of nanowires, and if we can rationally control the conductivity, then we can specify how a nanowire will perform in any type of device," Lauhon says. "This fundamental scientific understanding establishes a basis for engineering."

Understanding materials at such a small scale requires the right equipment. That's where Northwestern University Atomic and Nanoscale Characterization Experimental Center (NUANCE) comes in. NUANCE is headed by **Vinayak Dravid,** professor of materials science and engineering, and provides faculty members and students from three Northwestern schools with access to highly advanced instrumentation, including electron microscopes and tools for nanoscale fabrication, testing, and instrumentation. In addition to his work with NUANCE, Dravid has developed a nondestructive subsurface nanoscale imaging technique that has led to a start-up company for nanoscale metrology in microelectronics and biology.

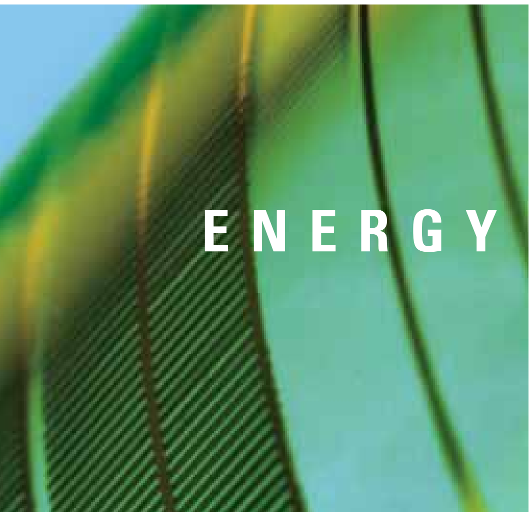
Another key resource on campus is the Northwestern University Center for Atom Probe Tomography (NUCAPT), which houses a 3-D atom-probe tomograph that combines a field-ion microscope and a special time-of-flight mass spectrometer. This very sophisticated and unique instrument allows for the atom-by-atom dissection of almost any material (Lauhon used it to characterize nanowire) and can analyze metals, semiconductors, ceramics, and organic materials. NUCAPT was founded by **David Seidman,** Walter P. Murphy Professor of Materials Science and Engineering. Seidman and his group research metallic alloys and interfaces on a subnanoscale level and interfacial problems that are relevant to the solid-state semiconductor industry. His research makes use of the 3-D atom-probe tomograph to determine, for example, the


Kung

relationships of a material's nanostructure to such properties as long-term stability at elevated temperatures.

Not all nanoscale research happens in the inorganic realm. **Bartosz Grzybowski,** Kenneth Burgess Professor in chemical and biological engineering and chemistry, combines elements of inorganic and organic chemistry, physics, and materials science to focus on the synthesis of new classes of micro- and nanostructured materials through self-assembly and self-organization. His group has created "cancer traps" that can separate cancer cells from normal cells and has also created self-erasing images by exploiting how nanoparticles assemble and disassemble under different wavelengths of light. Grzybowski will lead Northwestern's new Center for Integrated Training in Far-From-Equilibrium and Adaptive Materials, which will focus on synthesizing, characterizing, and understanding new classes of materials relevant to solar energy conversion, catalysis, and storage of electricity and hydrogen.

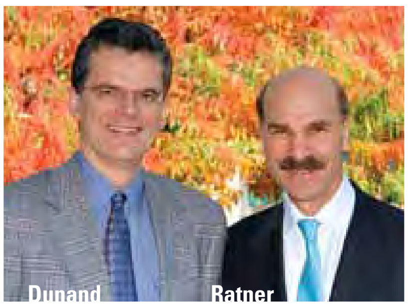
The future of nanotechnology is bright — in part because leaders in the field aim to teach it to the next generation of scientists and engineers. Bob Chang, for example, directs the National Center for Learning and Teaching in Nanoscale Science and Engineering, headquartered at Northwestern. The center is designed to build capacity in nanoscale science and engineering education and aims to equip future generations of students by advancing science, technology, engineering, and mathematics education. McCormick students play an important role in this forward-looking program. "I realized that it would be fantastic for young people at Northwestern to do nano education," Chang says. "There is no way that I could do a good job communicating to middle-school kids, but a younger generation could. We hope this way we can develop the next generation of leaders in nanoscale science and engineering." ■



Over the past several years the terms energy and sustainability have risen from buzzwords to vital areas of interest to scientists, politicians, and the general public. Funding for research in this area has swelled, and students especially have become hungry for courses and activities that allow them to be a part of the movement.

ENERGY AND SUSTAINABILITY

While researchers throughout Northwestern have worked on these problems for some time and McCormick has offered courses on the subject, the effort was far from unified. Seeing the need for greater collaboration in this area, Julio M. Ottino, dean of the McCormick School, initiated planning for what would in 2008 be launched as the Initiative for Sustainability and Energy at Northwestern (ISEN). **Mark Ratner,** Lawrence B. Dumas Distinguished University Professor in chemistry and materials science and engineering, and **David Dunand,** James N. and Margie M. Krebs Professor of Materials Science and Engineering, were tapped to direct the institute.



"We felt it was absolutely necessary for Northwestern as a teaching, training, and research institution to be involved in this area," says Ratner. "This is perhaps the most important scientifically based topic on society's agenda. Our responsibility is to champion energy and the environment to make them more prominent at the University and to make the University more prominent in these efforts." Added Dunand, "I think we're on the forefront of this broader vision of both energy and sustainability."

ISEN builds on Northwestern's established strengths in the social sciences, business, law, engineering, and the physical sciences. A recently formed partnership with Argonne National Laboratory has broadened its advantage in advanced research and has created important opportunities for collaboration: ISEN has sponsored two workshops with Argonne on energy supply and demand that mixed researchers from both institutions.

ISEN has also provided booster grants and matching funds for University research, helping to launch two new multimillion-dollar Energy Frontier Research Centers (funded in part by the U.S. Department of Energy's Office of Science). One center, led by **Bartosz Grzybowski,** Kenneth Burgess Professor in chemical and biological engineering and chemistry, strives to synthesize, characterize, and understand new classes of materials under conditions that are relevant to solar energy conversion, catalysis, and storage of electricity and hydrogen. The other, led by Michael Wasielewski, professor of chemistry, will address the basic steps of solar energy conversion — charge photogeneration, separation, and recombination — as well as charge and energy transfer among molecules, across interfaces, and through nanostructured architectures.

ISEN is active in the classroom as well. In 2009 Ratner and Dunand taught an undergraduate course on energy and sustainability in the 21st century, which was taken by students from throughout the University. "We think of ourselves as an entry point," Ratner says. "We hope that freshman or second-year students will take ISEN courses, find them interesting, and then go on to something more advanced."


Torkelson

ISEN has also given out grants to students for research and outreach projects and is beginning a specialized interdisciplinary cluster through the Graduate School in which a cohort of selected students will take ISEN courses in addition to their regular course work. ISEN is also heading up this year's One Book One Northwestern project, which will feature *New York Times* columnist Thomas Friedman's book *Hot, Flat, and Crowded: Why We Need a Green Revolution — and How It Can Renew America.* Other plans — perhaps a green roof on campus or a prize for undergraduate projects — are in the works. "We want this to be a part of the students' lives because they want it to be part of their lives," Ratner says. "They really care about this topic."


Broadbelt

Before ISEN was established, **Kimberly Gray,** professor of civil and environmental engineering, was one of McCormick's leaders in the area of sustainability. Gray recently took that role further by creating the Northwestern Institute for Sustainable Practices (ISP) in 2008. "I've been doing this for years," she says. "Everything I do concerns the environment."

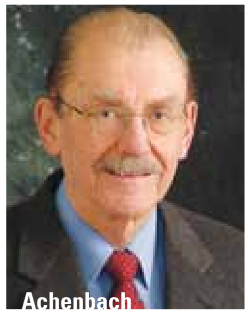
Gray studies solar-fuel generation and the use of ecologically based strategies for water treatment. Her determination to make sustainability a priority at Northwestern was an impetus in creating the institute. "I think it became very clear as oil prices were reaching their pinnacle that energy and its environmental impact and its intersection with sustainability were real issues that needed to be addressed," she says. "Northwestern needed to approach energy with a different spin."

Since its founding, ISP has held workshops; hosted the Dow Sustainability Innovation Student Challenge, which recognizes student design projects and research that offer creative solutions to the challenges of sustainability; brought in visiting scholars such as Doug Farr, a well-known architect focused on sustainable architecture and urban planning; and hosted a wide variety of guest speakers to lecture on the issues related to climate, transportation, alternative energy, and resource management. Gray also teaches the courses Sustainable Product Design and Development and Sustainable Solutions Practicum, in which student teams work on sustainability problems from industry. "We're also changing the engineering curriculum and trying to think about how we can integrate sustainability principles into core courses to teach students how to engineer products completely differently," Gray says. "I hope we can continue on this highly productive start."

One aspect of sustainability is creating materials that are more recyclable and biodegradable, and several McCormick professors are working on materials that won't be clogging future generations' landfills. **John Torkelson,** Walter P. Murphy Professor in chemical and biological engineering, is working to create biodegradable blends and nanocomposites with polymers made from renewable resources. **Linda Broadbelt,** Sarah Rebecca Roland Professor in chemical and biological engineering, is using mechanistic modeling of the decomposition of individual polymers and polymer mixtures during pyrolysis (a set of reactions) to improve polymer recycling procedures.

It is not possible to study energy and sustainability without addressing a major consumer of energy today: transportation. Enter **Harold Kung,** professor of chemical and biological engineering, who heads the Center for Energy Efficient Transportation. "Thirty percent of energy use is in transportation," he says. "If you know how to utilize energy for transportation more efficiently, you can reduce our dependence on energy and lower the rate of carbon dioxide that enters the atmosphere."

The center was created in 2007 to coordinate research and education on energy-efficient transportation, with an emphasis on


Achenbach

The field of mechanics addresses important questions: How long will an aircraft or building last? How will new kinds of electronics be created? How will nanoscale materials be used? From theoretical explorations to practical applications, McCormick faculty members have developed new ways of characterizing, evaluating, and modeling different materials and assessing how they behave.


Bažant

At the forefront of the field is **Jan Achenbach,** Walter P. Murphy Professor and McCormick School Professor in mechanical engineering, civil and environmental engineering, and engineering sciences and applied mathematics. A preeminent researcher in solid mechanics and quantitative nondestructive evaluation, Achenbach pioneered ultrasonic methods for the detection of cracks and corrosion in aircraft, leading to improved safety for aircraft structures throughout the world.

The detection of cracks and the prediction of failure also attracted the interest of **Ted Belytschko,** Walter P. Murphy Professor and McCormick School Professor in mechanical engineering. Belytschko created computational methods for modeling


Belytschko

materials. "We're capitalizing on the strengths of Northwestern — especially materials research," Kung says. "We have faculty members making cars more lightweight without sacrificing safety, and we'd like to improve the efficiency of the power train of the car."

Because McCormick hasn't focused research on the internal combustion engine, the center focuses many of its efforts on future propulsion systems, like battery-powered vehicles. Kung and others are trying to improve battery efficiency in hopes of creating one that can completely power cars that have attributes (such as safety, range, power, size) that are comparable to conventional vehicles. The efficiency of converting electricity into motion can be much higher than gasoline, but the most promising current rechargeable batteries — lithium ion batteries — are not competitive in cost, power, or energy densities. Kung is working to develop battery components to improve these. His research involves developing new materials for the battery components that store the charge. "One way to try to improve batteries is to change the components where the lithium goes in and out," Kung says. "We're researching those components and making them work in such a way that they can pack in 10 times the energy and run for 10 years without much degradation." Kung has assembled a team that includes **Chris Wolverton, Mark Hersam,** and **Mike Bedzyk,** professors of materials science and engineering, that has become part of Argonne National Laboratory's Energy Frontier Research Center for Electrical Energy Storage: Tailored Interfaces.

The transition to an electric car society will take a few decades of research and infrastructure improvement, but Kung is optimistic that electric cars are the future of transportation — and he's optimistic that Northwestern and McCormick can do their part in creating this new world. "We have the human resources to tackle this problem," he says. "We can conduct research and have an education program that will both enhance awareness and reduce our dependencies on limited energy resources. We can capitalize on our strengths to reduce energy consumption in transportation. With good planning and good research and development, we'll be able to achieve it in 30 or 40 years." ■

MECHANICS

the behavior of solids, with particular emphasis on failure and fracture. This research has found applications in simulating automobile crashworthiness and determining the safety of nuclear reactors.

Computer simulation models and methods are the purview of **Wing Kam Liu,** Walter P. Murphy Professor in mechanical engineering, whose research has applications in fluid and solid mechanics, structural mechanics, and materials design. Liu is currently investigating novel methods to study highly nonlinear problems involving physical phenomena in the fields of nanoengineering for medicine and biology.

An interest in the mechanics of structures turned a former bridge engineer into a world leader in the mechanics of solids. **Zdeněk Bažant,** Walter P. Murphy Professor and McCormick School Professor in civil and environmental engineering, discovered a simple size-effect law used for structural design and material characterization of fracture in concrete, composites, tough ceramics, rocks, ice, and other quasibrittle materials; developed effective and theoretically consistent methods for computer analysis of distributed cracking; and advanced the understanding of creep and hygrothermal effects in concrete structures. He also determined the causes of the collapse of the World Trade Center towers.

Also interested in the mechanics of composites is **Jianmin Qu,** who joined McCormick this fall as Walter P. Murphy Professor and chair of civil and environmental engineering. Qu's research focuses on fracture, fatigue, and defects in different materials as well as the nondestructive evaluation of advanced engineering materials — an area he learned while working as a graduate student with Achenbach.

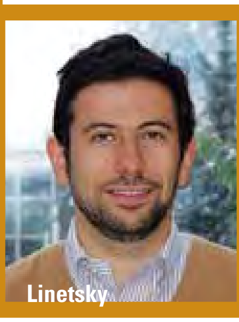
Characterizing materials is the aim of several McCormick researchers. **Cate Brinson,** Jerome B. Cohen Professor of Mechanical Engineering, studies materials such as bone and advanced nanomaterials, and her research helps enable new kinds of bone implants, sensors, and tailored nanocomposites. **Yonggang Huang,** Joseph Cummings Professor in civil and environmental engineering and mechanical engineering, develops new mechanics theories. This work has led to breakthroughs like twistable and stretchable electronics, a camera with a curved sensor array based on the human eye, and a flexible silicon-based photovoltaic device. Huang is also working on a theory that would fill the gap between atomistic models and conventional continuum theories, which could lead to flexible displays, electronic newspapers, and wearable systems for personal health monitoring.

Leon Keer, Walter P. Murphy Professor in civil and environmental engineering and mechanical engineering, researches how to minimize friction. His theoretical work enables the auto industry to create better bearings and gears. "These are improvements that people don't see but that result in far better performance of the things we use in everyday life," says Keer. ■

FINANCIAL ENGINEERING

During the 2008 financial crisis, many people asked, How could this happen? Now they ask, How can we prevent this from happening again? Two faculty members in the Department of Industrial Engineering and Management Sciences hope they have an answer in financial engineering.


Staum


Linetsky

Financial engineering is an interdisciplinary field that integrates methods and knowledge from mathematics, statistics, economics, operations research, and computer science. Financial engineers develop quantitative tools that help banks, manufacturing and service firms, and public institutions make disciplined financial decisions in the face of risk and uncertainty.

Jeremy Staum, Pentair-Nugent Professor in industrial engineering and management sciences, focuses on the big picture, creating computer simulations that can model an entire global financial institution's risk. These institutions have large portfolios that include investments in different parts of the world and in different markets. To consider the risk of that entire portfolio, an institution must take into account factors such as stock prices, interest rates, exchange rates, and credit risk.

Part of the recent financial crisis could be blamed on the fact that most financial institutions focus on protecting against losses 99 percent of the time. But there is no good model that shows what could happen under extreme scenarios, so banks are often unprepared when extreme events occur. The computation required to create better models is challenging and expensive, so Staum and his team are looking for more efficient algorithms to make the computing faster and cheaper. They are also working to combine several models and — looking at the degree of plausibility from each model — using that information to get a better picture of the risks that an institution faces.

Vadim Linetsky, Orrington Lunt Professor in industrial engineering and management sciences, focuses on modeling credit risk —

ART AND ENGINEERING

In addition to their work in the area of energy and sustainability, **Kimberly Gray,** professor of civil and environmental engineering and of chemical and biological engineering, and **David Dunand,** James N. and Margie M. Krebs Professor of Materials Science and Engineering, are part of a collaboration between Northwestern and the Art Institute of Chicago to help conserve and study works of art. The two organizations have received funding from the Andrew W. Mellon Foundation to link faculty and student experts with conservation scientists to enhance research on items of cultural importance. Projects have included work on Asian art — mainly jades and ancient Chinese bronzes — and studies of artists' materials and techniques to assist authentication and determine provenance.

Katherine Faber, Walter P. Murphy professor of materials science and engineering, has performed research to determine the mineral composition of ancient Chinese jades, while Dunand has analyzed the metallurgical composition of modern bronze sculptures from the collections of the Art Institute of Chicago and the Philadelphia Museum of Art and has used powerful X-rays from Argonne National Laboratory to investigate the structure and fabrication method of a 2,200-year-old Chinese bronze dagger-axe. Gray, using tiny samples from Georges Seurat's painting *A Sunday on La Grande Jatte,* has studied the aging process of the zinc yellow pigment. The group has also explored scientific techniques for examining art and has held several seminars on its work for scientists, curators, and conservators.


Faber

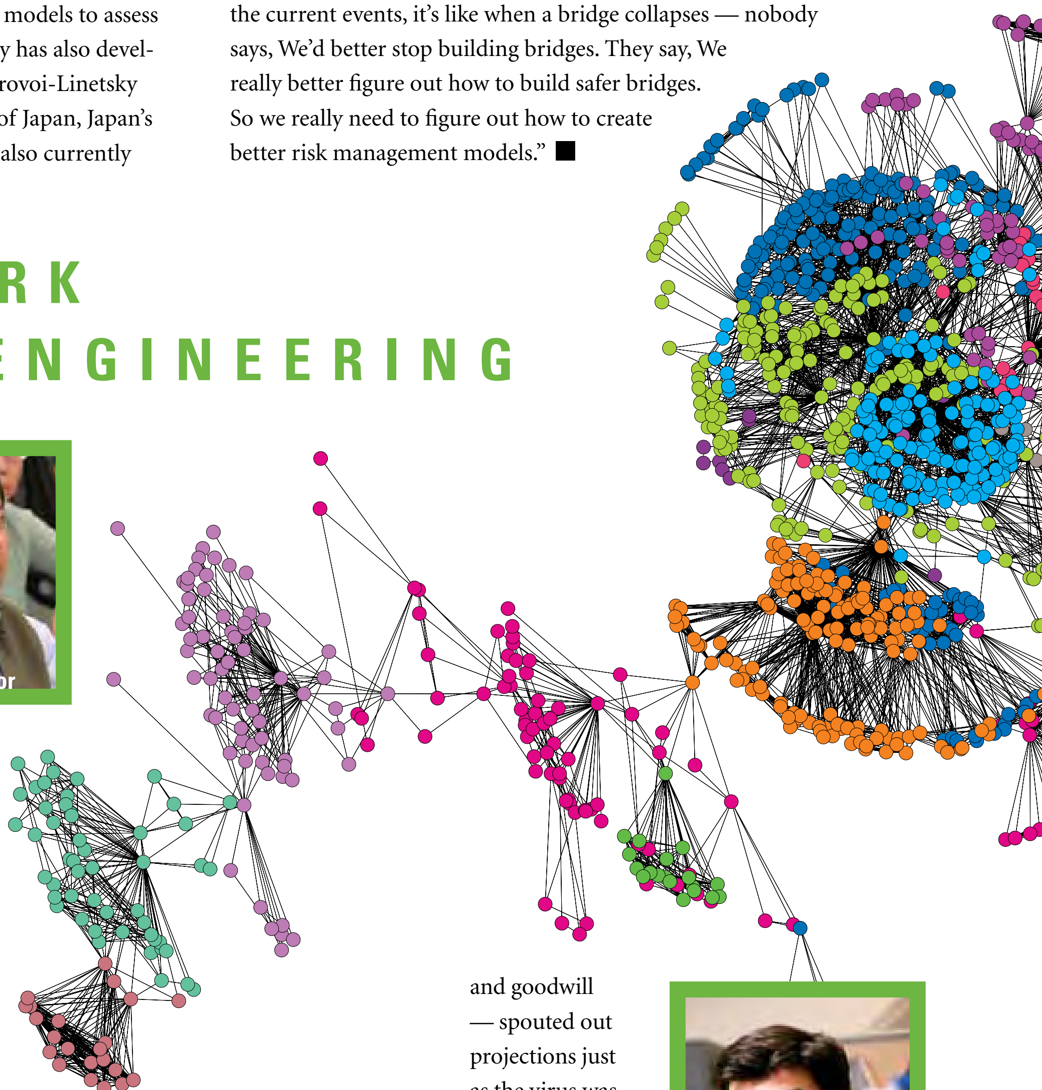
The partnership allows McCormick faculty to use their research in new ways. "We are problem solvers at heart," says Faber. "This partnership brought a whole new set of problems to us, allowing us to look at the past to try to figure out how something was made."

For Dunand, the project is a link to his own heritage. "I'm a metallurgist, and my grandfather was also a metallurgist with a wide range of interests, including archaeological materials," Dunand says. "My father was a curator of a small museum in Geneva that specializes in Asian art. I've always been very close to Asian art. Even though I am a scientist, the other part of my brain is active. For me, art is a very important part of life. It makes us human in our highly technological society. Discovery drives the scientist in me, but art allows for emotional expression."

The partnership with the Art Institute of Chicago provides unique research experiences and shows the broad applications of engineering. "We're working with beautiful objects, so it's a natural attraction," says Faber. "These objects provide an opportunity to attract more people to science through art." ■

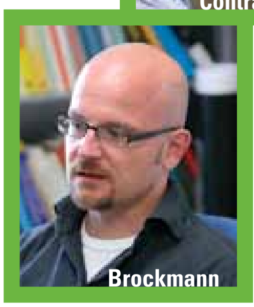
the risk of default by a corporation or an individual on a financial obligation, such as a bond, loan, mortgage, or pension. Linetsky's work is distinctive in that it creates a model combining both market and credit risk. His current focus is on risk in financing an asset acquisition, such as a real estate or aircraft mortgage, and he is working with the global aviation industry on creating better models to assess risk in loans to airlines to purchase aircraft. Linetsky has also developed an interest-rate model — called the Black-Gorovoi-Linetsky model — that was eventually adopted by the Bank of Japan, Japan's version of the Federal Reserve. He and his students also currently work on modeling highly volatile commodity and energy markets and pricing commodity and energy contracts used to manage risk in these markets.

"Over the past 11 years we have faced crisis after global financial crisis in which people's risk models broke down," Staum says. "With the current events, it's like when a bridge collapses — nobody says, We'd better stop building bridges. They say, We really better figure out how to build safer bridges. So we really need to figure out how to create better risk management models." ■



NETWORK ENGINEERING

Contractor



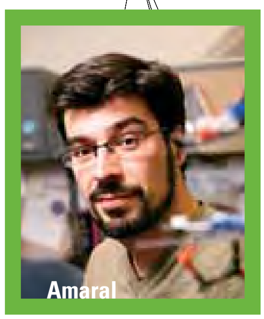
Brockmann

From the moment we get up in the morning, we are entangled in a mass of networks. Sitting in traffic on the way to work. Exchanging money for a cup of coffee. Checking and sending e-mail at work, then collaborating on a team project. Playing online games with friends. Checking e-mail. Sitting in traffic on the way home, then checking e-mail again. Even as we go to sleep for the night, we're still networking: the cells inside our bodies — the proteins and genes — are constantly interacting with one another.

These actions, these connections, are the networks that define our lives. A century ago, a person's networks wouldn't likely reach much further than his or her hometown. But the leaps and bounds of technology in recent decades have turned our lives into vast, complicated networks of communication and travel. Studying these networks has become essential to understanding everything from how disease travels to how we make new friends (or keep in touch with old ones) in virtual space. It takes social scientists, physicists, mathematicians, and engineers — collaborations across disciplines — and McCormick has positioned itself at the forefront of network research.

Take, for example, swine flu. From the moment the first signs of the flu strain made the headlines in Mexico, **Dirk Brockmann,** associate professor of engineering sciences and applied mathematics, and his research group got to work. Brockmann uses high-performance computer clusters to run large-scale simulations of the spread of pandemics. In a 2006 study Brockmann used data from WheresGeorge.com — a site where users enter the serial numbers from dollar bills to track the travels of currency — to create a model for predicting the probability of a bill staying within a 10-kilometer radius over time. From that information Brockmann found a key factor in his disease-spread modeling approach: very accurate datasets on human mobility.

Fast forward to April 2009 and the swine flu panic. Brockmann's computer simulations — which started running on a Friday night and didn't stop for days, leaving his bleary-eyed graduate students to subsist on pizza and goodwill — spouted out projections just as the virus was making headlines worldwide. The original estimate: 1,700 cases nationwide, which seemed to help calm the frenzy. For his work Brockmann got a headline on the front page of the *New York Times.* Simulations continued and changed as new information came in, and Brockmann and his group ultimately shifted their focus toward creating a detailed analysis of the geographical pattern of infection and assessing the long-term impacts of the new virus. "We are extracting information about this virus that will allow for a better understanding of the disease and more accurate models in the future," Brockmann says.



Amaral

While Brockmann tracks disease, **Luis Amaral,** professor of chemical and biological engineering, hopes his research will eventually help treat it. Amaral — like Brockmann, originally trained as a physicist — has studied a wide range of networks by developing computer models to explain them. He has modeled everything from how social networks can substitute for central mechanisms in decision making to how prices fluctuate in political prediction markets and what affects people's e-mail behavior.

Now, with the funding of the Howard Hughes Medical Institute, he's tackling a tiny area with huge implications: he's trying to create the Google Maps of cellular organization. Cells — with their thousands of genes and proteins and the complex interactions between them — remain a mysterious network. Amaral says navigating such information could be just as easy as navigating a journey in a car; all we need is a good map. Amaral's computational methods will act as the cartographer as he creates interactive maps of cells, which he hopes will speed development of smarter therapies for a range of diseases. "I hope to explore new directions and ideas within these networks," he says. "Success in science often works this way. The pursuit of new and risky ideas can produce significant results."

While Brockmann and Amaral's networks are biological, **Noshir Contractor** studies networks that are both personal and virtual. Contractor, Jane S. and William J. White Professor of Behavioral Sciences, professor of industrial engineering and management sciences, and professor of communication studies at the School of Communication, develops and tests theories and methods of network science to map, understand, and enable more effective networks in business, science, and engineering communities, disaster response teams, public health networks, digital media and learning networks, and virtual worlds, such as Second Life.

Recently Contractor's lab has helped enable virtual worlds in the science community — specifically, a web service where researchers can get recommendations to help them form effective teams. Inspired by services like Amazon.com that recommend books based on one's interest, Contractor's lab has developed algorithms and technologies to help a researcher identify people, tools, documents, and datasets based on their interests and their existing social networks. Contractor wants to find out what makes some teams successful while others fail miserably.

"Sometimes groups come together that are incredibly successful, and other times they are not," Contractor says. "What makes the difference? It's not just because they didn't have the right expertise — people with good expertise come together and fail. Like in Hollywood: you can have an all-star cast, and yet the movie doesn't always do well. A lot of social network analysis is an effort to see how we can improve our ability as a society to assemble teams that are more effective."

Other researchers, such as **Seyed Iravani,** associate professor of industrial engineering and management sciences, perform network research aimed at optimizing the workplace. Iravani's research focuses on the optimization of queuing systems, white collar work and service operations systems, and manufacturing and supply chain management.

All of these faculty members are interested in what are known as complex systems: those that develop without any external organizing principle being applied. Such systems cannot be studied as a collection of parts, only as a whole. For example, studying cars themselves does not give researchers any sort of understanding of how traffic flows, just as studying neurons doesn't give researchers any insight into consciousness. The hub of this research is the Northwestern Institute on Complex Systems, directed by **William Kath,** professor of engineering sciences and applied mathematics, and Brian Uzzi, Richard L. Thomas Distinguished Professor of Leadership at the Kellogg School. Julio M. Ottino, dean of McCormick, was instrumental in creating the institute in 2004. "Investigating how complex networks operate is the only way to make sensible decisions about them," Ottino says. "This requires a multidisciplinary approach and a new way of thinking. This is the future of network research." ■

COMPUTER

The Internet has given rise to entirely new type of businesses — and with it, entirely new business models. To capitalize on the possibilities provided by new online auction and prediction capabilities and increased computational power, McCormick researchers at the interface of computer science and economics are merging the two fields to solve new problems.

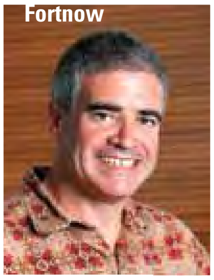
Nicole Immorlica and **Jason Hartline,** assistant professors of electrical engineering and computer science, and **Lance Fortnow,** professor of electrical engineering and computer science, form the new economics group in the Department of Electrical Engineering and Computer Science. Their work is augmented by strong relationships with Kellogg's storied game theory researchers; Rakesh Vohra, J. L. and Helen Kellogg Professor of Managerial Economics and Decision Sciences at Kellogg, helps to facilitate that interaction.

One focus of research involves online auctions, which abound on the Internet and provide the mechanism for purchasing everything from online advertisements to knickknacks from a garage halfway around the world. These auctions are a relatively new phenomenon — one that has put a new spin on economic auction theories. Understanding how to value online goods presents new challenges that require different solutions.

An interesting application of the research occurring at McCormick involves pricing goods in an online environment — notably online products for which the supply is

SCIENCE FOR ECONOMICS

unlimited, such as music downloads. Every potential buyer assigns a real value to a given object, but when asked to state that value, a person is unlikely to readily provide that information. The only certainty is that buyers will act in their own self-interest. "You solicit information from users, and they can manipulate what they say," Immorlica explains. "We're trying to approximate a value in the absence of true information."


Fortnow


Immorlica


Hartline

Using these approximate values, research undertaken at Northwestern can help determine how to set up auctions that attain goals such as maximum profitability. McCormick researchers also study broader areas such as predictability and prediction markets, where minimarkets are created to predict outcomes based on the price of a security. Prediction markets saw a rise in popularity during the 2008 election, often revealing trends days before pollsters saw them. By understanding these markets, businesses can predict product sales or even choose products and release dates. McCormick faculty working in this area also aim to minimize the computational power needed to solve these complex problems. Doing so, computer scientists can better use available computational power to meet their needs.

While Kellogg has long had a significant presence in the field of game theory, this activity at the intersection of computer science and game theory is a recent development at McCormick. Immorlica, Fortnow, and Hartline have all arrived within the past three years, and they've already formed strong connections across campus and introduced new course work that incorporates these concepts.

"We have the largest group of people doing game theory at any one institution in the world," says Vohra. "This new area helps cement Northwestern's reputation in game theory. This is a growing field, and we now have a substantial strength that we didn't have before." ■

HEALTH-CARE OPERATIONS

When should someone be screened for cancer? How do you keep track of patients in a developing country? How do you deliver asthma education to inner-city schools? These are the questions of health-care engineers — researchers who apply analysis, statistics, simulation, and optimization methods to health-care operations. Their work involves many different settings — hospitals, rural clinics, schools — but the common goal is finding new ways to provide the best possible medical outcome.

For **Gordon Hazen,** professor of industrial engineering and management sciences, the best outcome is the most cost-effective. Hazen performs analyses of medical interventions (surgeries and screenings, for example) to see how cost-effective they are in various situations. His research involves stochastic and probabilistic models that aim to predict a person's future based on whether and when a particular intervention is done.

Benjamin Armbruster, assistant professor of industrial engineering and management sciences, addresses a much more specific problem: HIV testing. Normal interventions for HIV involve screening programs; Armbruster is studying whether a different approach called contact tracing — interviewing infected people, learning whom they might have infected, and then seeking out and testing those people — could be more effective. Armbruster hopes to make the case for contact tracing of HIV cases in Africa. "Currently most people in Africa find out if they're infected through screening programs," he says. "As far as I know, nobody has done contact tracing or looked at whether this might be a worthwhile idea."

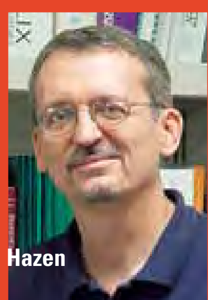

Smilowitz

McCormick has launched several health-care projects in Africa. **Matt Glucksberg** and **David Kelso,** professors of biomedical engineering, are involved with the Center for Innovation in Global Health Technologies and are overseeing the development of a tuberculosis tracking system in South Africa. Northwestern study abroad students are working to monitor diagnostic and treatment regimens in a Cape Town clinic, where effective patient tracking is hampered by inefficient filing and communications systems as well as a lack of incentives for patients to follow up after office visits. Students are using the ideas of both industrial engineering and organizational behavior to find solutions.

Health-care operations problems aren't limited to developing countries, as **Karen Smilowitz,** associate professor of industrial engineering and management sciences and William A. Patterson Junior Professor in Transportation, has learned. With Sarang Deo in the Kellogg School of Management and her students, she is collaborating with the nonprofit Mobile CARE Foundation, which delivers asthma treatment and screening to Chicago Public Schools. Increased demands and a stagnant budget have left the foundation wondering how to do more with less. "Our students are looking at Mobile CARE's metrics and best practices to determine areas for operational improvement," Smilowitz says. "We're trying to find ways to maintain the foundation's objective of greater care for patients while addressing their operational issues." ■


Armbruster


Glucksberg Kelso


Hazen

ROBOTICS

Science fiction often involves a future where humans and robots live together in a harmonious (or not so harmonious) existence. While that future is still far off, machines are playing a greater role in our increasingly automated life. Studying how humans and machines interact is the passion of several McCormick professors.

The Laboratory for Intelligent Mechanical Systems — directed by **Michael Peshkin, Ed Colgate,** and **Kevin Lynch,** professors of mechanical engineering, along with **Todd Murphey,** assistant professor of mechanical engineering — researches, among other topics, human-machine interactions.

The lab is the birthplace of the cobot (short for collaborative robot), which is a robot that works in close and natural interaction with a person. Cobots can be high-quality haptic displays, rehabilitation devices, and assistive devices for workers in automobile assembly. This last application has developed into a spinoff company whose products are now being used in auto plants around the world.


Colgate

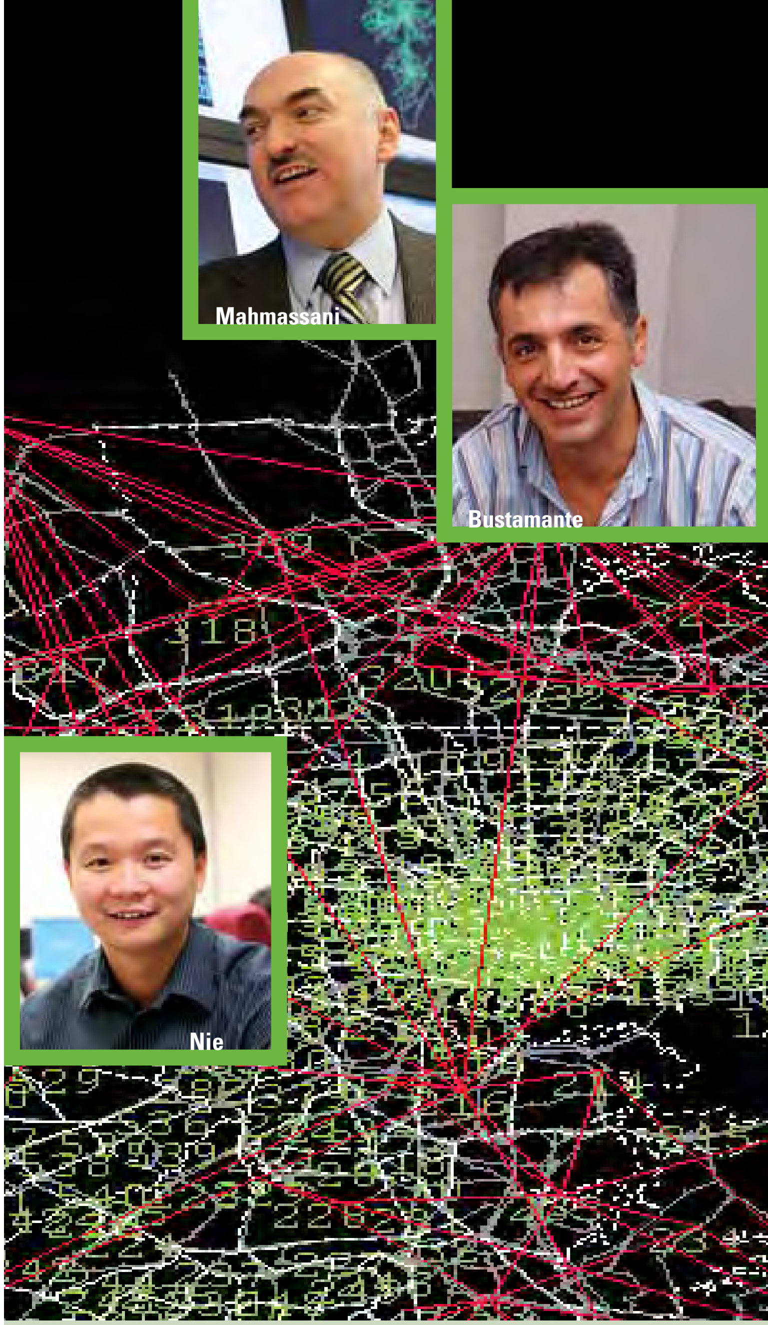
Researchers in the lab also study robotic motion planning and control (juggling, throwing, pushing, rolling, vibration), and they recently developed a tactile display that can create a perception of surface features on a flat glass plate under software control. Researchers also frequently collaborate on rehabilitation robotic projects with members of the Department of Physical Therapy in the Feinberg School of Medicine and with the sensory motor performance group at the Rehabilitation Institute of Chicago. Collaborations have included new types of prosthetic limbs and stroke rehabilitation devices. As a result of this work a second spin-off company, Kinea Design, was founded in 2003. The company has created devices to help rehab patients walk and balance and measure their muscle recovery.


Lynch


Peshkin

McCormick researchers don't do it alone: students are often credited as co-inventors on patents, and many have gone on to work for the spin-off companies that have emerged from the lab. Student projects in robotics have ranged from a computer-assisted knee replacement to a robotic rodent.

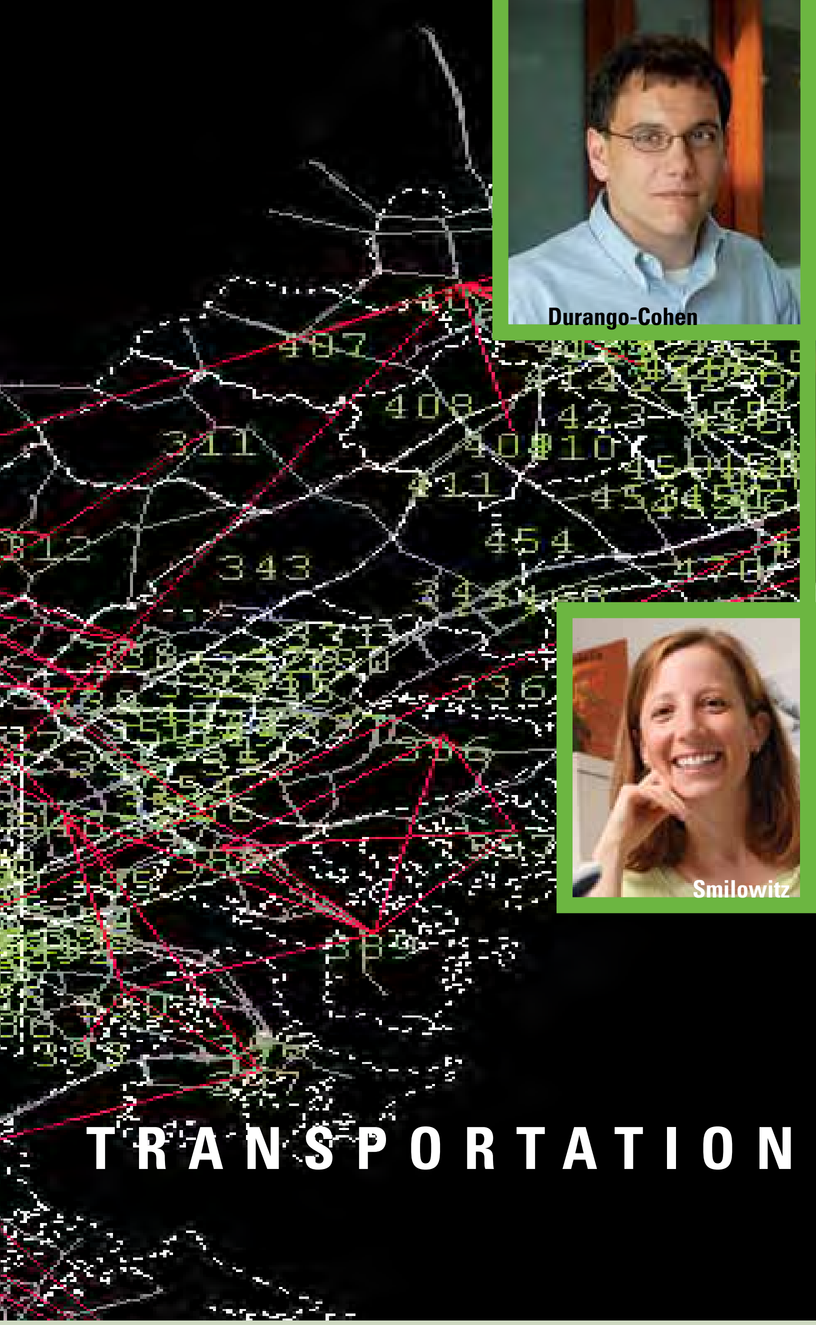
"Robotics today is less about machines acting like people and more about machines interacting with people," says Peshkin. "Our lab is working in haptics, prosthetics, tactile display. It's all about interface with the human user." ■


Mahmassani
Bustamante
Nie

Transportation is at a tipping point: with the nation's infrastructure crumbling, urban and suburban traffic congestion overwhelming, and concerns over greenhouse gas emissions ever increasing, it's clear the country can't continue on the same path as it has been on for the past 60 years. Change — in this case, massive change — is always resisted: politically, culturally, and economically. But faculty members at the McCormick School keep pushing and creating new models and technologies for this necessary change.

"Transportation is a particularly interesting area because it's at the intersection of technology and people and the behavior of people," says **Joseph Schofer,** professor of civil and environmental engineering. Schofer should know: for the past several decades he has studied the planning and management of transportation systems from the perspectives of policy, planning, design, and operations.

Schofer directs the Infrastructure Technology Institute, which develops strategies and tools to protect and improve the condition, capacity, and performance of the nation's highway, railroad, and mass-transit infrastructure systems. A major research focal



Durango-Cohen

Schofer

Smilowitz

TRANSPORTATION ENGINEERING

point for the center — one that has gotten more attention since the August 2007 bridge collapse in Minneapolis — is using sensors to measure the condition of a structure in real time. The institute currently has sensors on a bridge in Louisville, Kentucky, that transmit condition and performance data back to the lab at Northwestern.

That's where **Pablo Durango-Cohen,** associate professor of civil and environmental engineering, comes in. "The problem I tackle is how to process these data efficiently to obtain information and use them to decide what actions we'd like to take and when we should take them," says Durango-Cohen, who has a background in industrial engineering. He is working on models to determine how to best synchronize infrastructure work — and how to finance it, as well.

"We are modeling interactions between governments and private agents who wish to invest and develop or take over infrastructure," he says. "In the United States alone, we spend tens of billions of dollars a year on the maintenance of roads and bridges. There is a huge potential not only for direct savings but also indirect savings with greater mobility."

Besides the roadwork that results from infrastructure problems, one of the main complaints of drivers is congestion. How congestion happens is an area of interest for **Yu Marco Nie,** assistant professor of civil and environmental engineering, who researches traffic-flow theory and traffic simulation. Nie studies the mechanisms causing oscillations and gridlocks in urban traffic, and he has developed a traffic simulation platform that integrates a variety of traffic-flow models.

But unless overall demand decreases or available supply increases, congestion may ultimately be a matter of better managing existing facilities, including the communication of information to users. Existing variable message signs that are based on roadside sensors can tell drivers of current congestion, but they can't predict future traffic problems, so they aren't ideal. **Hani Mahmassani,** professor of civil and environmental engineering, William A. Patterson Distinguished Chair in Transportation, and director of the Transportation Center, is researching the use of real-time information — through wireless location and communication devices, vehicle sensors, and variable displays — to give drivers information about traffic in the area and enable system managers to operate their networks and distribution systems optimally.

Other faculty members, such as **Fabian Bustamante,** associate professor of electrical engineering and computer science, and **Karen Smilowitz,** associate professor of industrial engineering and management sciences and William A. Patterson Junior Professor in Transportation, are working on a project called C3, which stands for "car-to-car cooperation." The project explores what would happen if vehicles had the ability to communicate with each other. In such a model, vehicles would be equipped with wireless communicators, GPS navigators, and digital maps so vehicles could exchange information about infrastructure, road conditions, and traffic. "This creates a wireless environment that is completely free of infrastructure," Bustamante says. "It's more resilient, dynamic, and scalable but also more complex than current approaches."

Another possible solution for congestion is so-called congestion pricing, or requiring vehicles to pay fees to drive in a certain area at a certain time. "We have developed methods that can predict traffic flows and set prices accordingly to prevent congestion proactively," Mahmassani says. Considering the state of infrastructure funding, Schofer thinks more and more road systems will be financed this way. "My prediction is that in another 10 years, you're going to see that as a very common way to finance road systems," says Schofer. "Charging for driving at a certain time is a fairer and more efficient way to collect revenue."

Even if traffic is relieved via congestion pricing, it still leaves a major problem: pollution. The average car emits more than 11,000 pounds of carbon dioxide into the atmosphere each year. Long-term solutions will certainly involve using different sources of energy, but what can be done now?

Schofer and Durango-Cohen, along with **Kimberly Gray,** professor of civil and environmental engineering, are trying to assess the environmental impact of infrastructure and how it shifts demand to different modes of transport. They are working on a case study that looks at various Chicago neighborhoods to assess how greenhouse gas emissions and energy consumption relate to how close people live to mass transit. Mahmassani and his group have developed methodologies to analyze the European intermodal rail network to shift freight from trucks to rail to reduce environmental impact.

"The transportation sector is a major consumer of energy and a major polluter," Mahmassani says. "Solutions to the global problem of pollution must address transportation issues. By making our systems less congested and more efficient, we tend to also make them more environmentally friendly."

To find solutions to these myriad problems, faculty members must not only study transportation and infrastructure but also sociology, economics, and political science. The base for these multifaceted studies is the Transportation Center, a leading interdisciplinary education and research center founded in 1954 that serves industry, government, and the public. "It was revolutionary when it was conceived," says Mahmassani. "It is a very dynamic environment. We interact very closely with the transportation industry: our business advisory committee includes more than 75 different companies, including airlines, railroads, and shippers. It's a source of real-world insights and problems that our faculty and students work on."

Finding solutions to problems doesn't matter if you aren't working closely with both government and industry, Schofer says. "If you don't work with the customer, then you're distant from the problem. Grounding in reality is tremendously important for the quality of our research and the impact it produces."

Working with industry doesn't always mean working with the Department of Transportation or industry bigwigs — it also means using transportation research to help nonprofits. Smilowitz has worked with both a local suburban library system and a local food bank to optimize how books and food are distributed. Besides having problems that they often lack the budget and knowledge to solve, these organizations have different needs than for-profit companies. "With a nonprofit, the goals change," Smilowitz says. "You can't just take a commercial model and apply it, since maximizing profit and minimizing cost aren't necessarily the goals." Smilowitz and her colleagues have found the best way to distribute books in the budget-constrained library system and helped the food bank find the best way to pair up donors and recipients and how to best design delivery routes to serve people. "It's great to work with organizations that need our help," Smilowitz says.

It's also a good lesson for students, who work with faculty on many transportation problems. Says Mahmassani: "Transportation engineers design solutions, and we teach students the skills to design solutions to problems like these." ■

The writing is on the wall: the world of journalism needs innovation. And who knows innovation better than engineers? This logic brought together McCormick and Northwestern's Medill School of Journalism in a multidisciplinary partnership that has produced some truly newsworthy ideas.

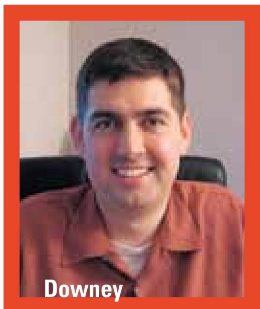
The partnership started more than a year ago after **Kristian Hammond,** professor of electrical engineering and computer science and codirector of Northwestern's InfoLab, created News at Seven, a customized, automated online newscast that automatically identifies who's being talked about in the news, finds images and videos that go along with that story, and presents the story via two computer-animated newscasters.

That caught the attention of John Lavine, dean of Medill, and the two schools starting talking about how they could work together. The result — a course called Innovation in Technology Media in Journalism, taught by Hammond, **Larry Birnbaum,** associate professor of electrical engineering and computer

DATA

In our increasingly digital world, information technology plays an ever-more-important role in the way business and research functions. In the computer engineering and systems division of the Department of Electrical Engineering and Computer Science, faculty members have responded to this growing need by conducting research in critical areas such as computer architecture, high-performance computing, networks, and operating systems. But as information technology grows, another area of computer systems — databases — plays a vital role in storing information. As a result there is a need for better tools to extract specific data from databases.

Alok Choudhary, John G. Searle Professor in electrical engineering and computer science and director of the Center for Ultra-scale Computing and Information Security, and his research group have recently focused on creating massive data mining algorithms and software that will allow users to search through petabytes of data. (A petabyte is a quadrillion bytes.) Data mining programs have uses in many areas, including business (customer relations, risk management, fraud


Downey


Choudhary

COMPUTER SCIENCE FOR MEDIA

science and codirector of the InfoLab, and several journalism professors — brought together undergraduate computer science students and graduate journalism students. The resulting projects drew the interest of media organizations around the world. "The idea is to do research on actual pressing problems in the world of journalism and find a combination of technological and editorial approaches that can help solve those problems," Hammond says.


Birnbaum


Hammond

Once the teams learned about each other's specialties — for computer science students, it was learning editorial values and how to create products for news consumers; for journalism students, it was learning what sort of technology was feasible — they worked together to create five new systems for media. One program allows journalists to run web and archive searches on text highlighted in Microsoft Word, while another allows iPhone users to download selected news stories based on the amount of time they have to read them. Groups also came up with tools to integrate the social media site Twitter into news web sites and to send news articles to Twitter users based on their recent tweets.

The project garnering the most attention was a system that takes readily available information about sports games — box scores and play-by-plays — and automatically generates a news story that captures the overall highlights and dynamics of the game, including a headline and a photo of the most important player. Students stayed on campus last summer to improve the tool in the InfoLab. "We want to be known as the university where students come to learn how to innovate with technology and journalism," Hammond says. "We want it known in the industry that this is where you go to hire people who know how to innovate. That's the way you change things." Says Birnbaum: "With our combination of world-class engineering and journalism schools, Northwestern is phenomenally well situated to lead these solutions. We're in a position where we can really do something special." ■

MINING

detection), science (astrophysics, climate modeling, particle physics), and biotechnology (protein identification, drug discovery). Choudhary's data mining software includes such processes as high-dimensional clustering, classification, and deviation detection, which help businesses understand customers' preferences and help enable recommendation tools like the one used by Amazon.com. He has also developed software to mine massive amounts of multidimensional data produced by supercomputer simulations, telescopes, and satellites useful in climatology, energy, medicine, and other fields. **Doug Downey,** assistant professor of electrical engineering and computer science, uses similar techniques to optimize Internet search engines. He was involved in the KnowItAll project, which created TextRunner, a search engine that searches hundreds of millions of assertions extracted from 500 million high-quality web pages.

"Digital technologies are fueling tremendous data growth, and we're developing next-generation systems for data mining," Choudhary says. "We're working with faculty members across the University to perform highly innovative research in many synergistic areas of ultrascale computing and information technologies." ■

DESIGN

The word "design" often evokes aesthetics: a beautiful car, a striking work of art. But design — human-centered design — is and should be based on usability. As **Don Norman,** a noted design expert who is Breed Professor of Design and professor of electrical engineering and computer science, says, "Far too many items in the world are designed, constructed, and foisted upon us with no understanding — or even care — for how we will use them."

Bad design affects everything from products to services to operations. So how do designers and engineers overcome such an unfortunate trend? By exploring, brainstorming, prototyping, and testing — and by revising their concepts based on feedback. "That is human-centered design," says **Ed Colgate,** professor of mechanical engineering. "That is design thinking."

The concept of design thinking is the hallmark of McCormick's emergence as a major player in design among engineering schools. Over the past decade McCormick has molded curricula, programs, spaces, and extracurricular activities to teach students human-centered design in context. That means a commitment to framing the problem alongside solving the problem — making sure the problem you're solving is the actual problem.

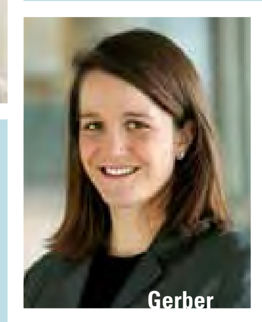
"You start by looking at people's needs," says Norman. "Does the solution you've found satisfy? Is it enjoyable or pleasurable? Making things enjoyable and pleasurable is not common in engineering schools. What's unique about us is that we bring this human-centered aspect to engineering."

McCormick began focusing on design in 1995, when then-dean Jerome Cohen challenged McCormick faculty to create a new kind of curriculum for freshman students. The result was Engineering First, an innovative first-year curriculum for undergraduates. A key part of this curriculum is Engineering Design and Communication, a two-quarter sequence that teaches first-year students how to approach unstructured problems from real clients and create and communicate solutions. "We started pretty early on this culture of design," Colgate says. "The idea was that we really wanted to increase the appreciation people have for design as an intellectual activity."

In 2001 the Ford Motor Company donated $10 million to build a state-of-the-art building to house McCormick's expanding design curriculum. In 2005 the building opened and became the home base for an undergraduate certificate in design, a degree in manufacturing and design engineering, and several graduate programs, including the


Colgate


Norman


Gerber

MMM program (a combined MBA and master of engineering management degree) and a master of product development.

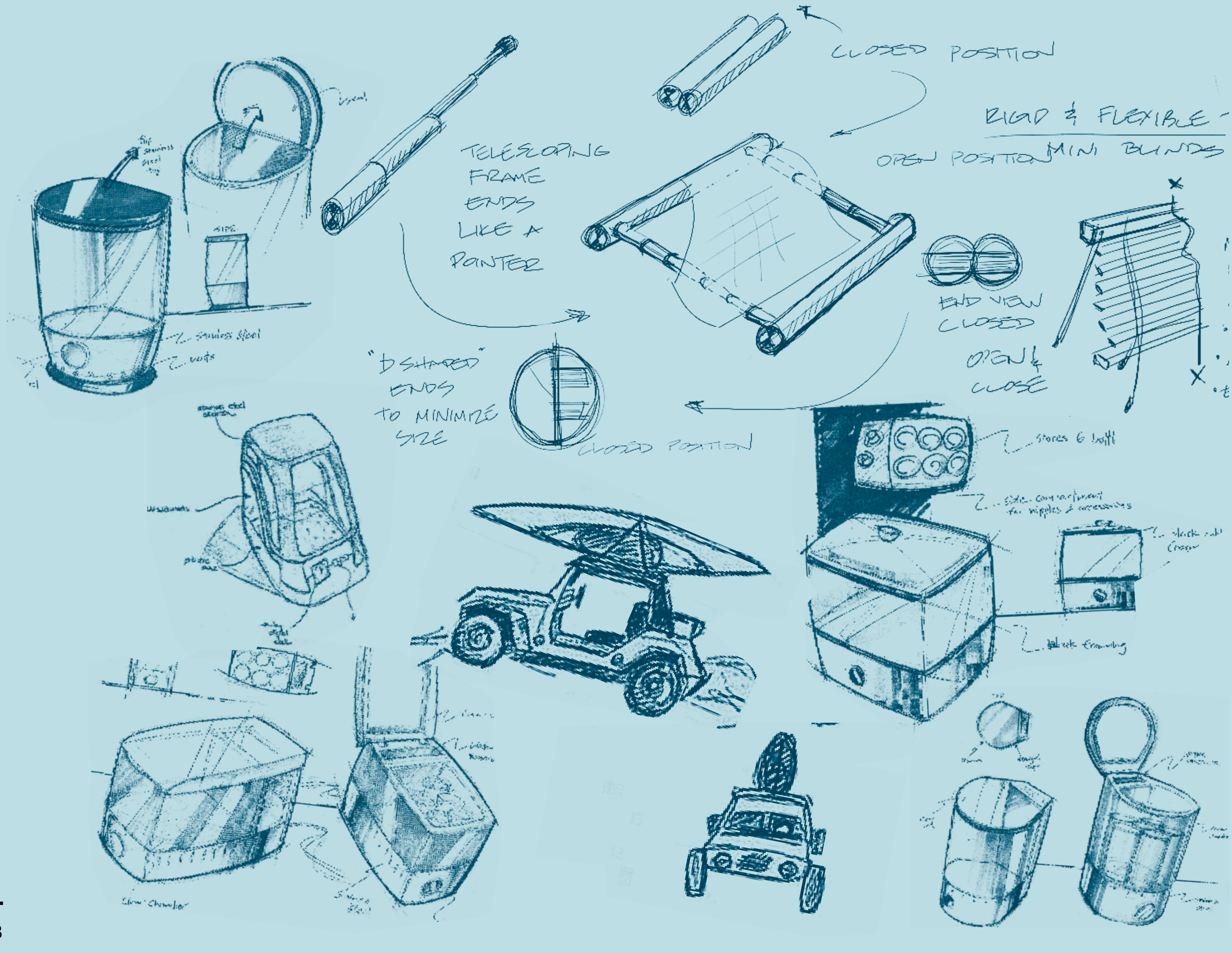
Then in 2007, Gordon and Carole Segal, cofounders of Crate & Barrel, made a significant donation to endow McCormick's Segal Design Institute, directed by Norman and Colgate. On the heels of the donation, the school soon added a master's program in engineering design and innovation, a full-time, one-year program that introduces engineers to design thinking.

Besides design thinking, creativity is the common thread that connects these programs. In his vision for McCormick, Dean Julio M. Ottino says that while engineering requires analysis, logic, and math, it also requires creative, divergent thinking if innovation is to be achieved. Norman says creativity is inherent to the field: "Engineers and scientists are really creative. Where do you think the great engineering ideas and insights come from? We're taking some of that creativity and moving it to the world of products and services, and it's a wonderful fit."

Norman should know: he's the author of several bestselling books on everyday design and, in addition to codirecting the Segal Design Institute, codirects the MMM program. He is also the cofounder of the Nielsen Norman Group, an executive consulting firm that helps companies produce human-centered products and services. "Design is really where the action is," he says. "Design is about every action of the company."

Colgate came to design from an engineering perspective. He and **Michael Peshkin,** professor of mechanical engineering, created the company Cobotics, which is a leading provider of human interface technologies for the industrial marketplace. "I always used engineering design pretty heavily in my work," Colgate says. "When we started the company, I was passionate about engineering challenges, but I found that the ones that really mattered were the business design challenges: what do people want, what do people need? I feel passionately that this is an important thing for engineers to learn."

Engineering design is also a strength of **Wei Chen,** Wilson-Cook Professor in engineering design, who has made significant contributions to the field of theoretical and



computational engineering design. At Northwestern she established the Integrated Design Automation Laboratory, a research program that develops rational design methods based on mathematical optimization techniques and statistical methods for use in complex design and manufacturing problems. She is also the cofounder and director of the new interdisciplinary doctoral cluster in predictive science and engineering design, a program aimed at integrating scientific, physics-based modeling and simulation into the design of innovative "engineered" systems. Related to human-centered design, Chen's research team has been developing analytical methods for integrating consumer preference modeling into product design.


Chen

Another faculty member, **Richard Lueptow,** professor of mechanical engineering and codirector of the master's program in product development (MPD), has been a design presence at McCormick for more than 20 years. He's a longtime teacher of capstone design courses, and his book on engineering graphics is used in undergraduate courses.

The director of the MPD program, **Walter Herbst,** also has several design roles. He is a clinical professor of mechanical engineering as well as chair of one of the largest independently owned design firms in the country, Herbst Lazar Bell Inc. Herbst holds more than 85 patents in hardware, housewares, and medical products.

Hiring faculty with a passion for design has been key in recent years. Bruce Mau, famous as a designer and for his "Massive Change" exhibition and book project, has recently become a distinguished fellow of the Segal Design Institute. **Liz Gerber,** who helped develop Stanford's Hasso Plattner Institute for Design, started as an assistant professor at Segal in fall 2008. Gerber spent her graduate school years studying the psychology of design practices and researching how firms adopt design practices as a means to innovation. "My vision is to create tools and practices so that everybody has a sense of creative confidence and the ability to design the world around them," she says.

One of Gerber's first projects was the creation of a program called Design for America. "When I arrived at Northwestern, I looked around at the students and thought there was a real opportunity to direct their excitement for social impact," she says. She and Ottino started talking about a service-based volunteer program similar to Teach for America in which students would better communities through human-centered design, and soon a student group was formed.


Herbst

At first, the group struggled to decide where to begin. "We met every Thursday for an hour, and there'd be 20 people in a room with a whiteboard, and we'd say, 'What problems are we going to solve?'" says Yuri Malina, a Weinberg College student involved with the group. Within a few months, however, they had won an award in the DiabetesMine.com design challenge, which asked teams to create new tools for improving the lives of people with diabetes. The Design for America team created Jerry the Bear with Diabetes, an interactive stuffed toy and web site for children with diabetes.

The future of design at McCormick will involve more seminars, more talks, more reaching across the boundaries of disciplines, and more faculty members who will make the intellectual life of design more vibrant. "We're busy people at Segal," Colgate says. "We're really creating a design community." ■

INNOVATIVE IMAGING

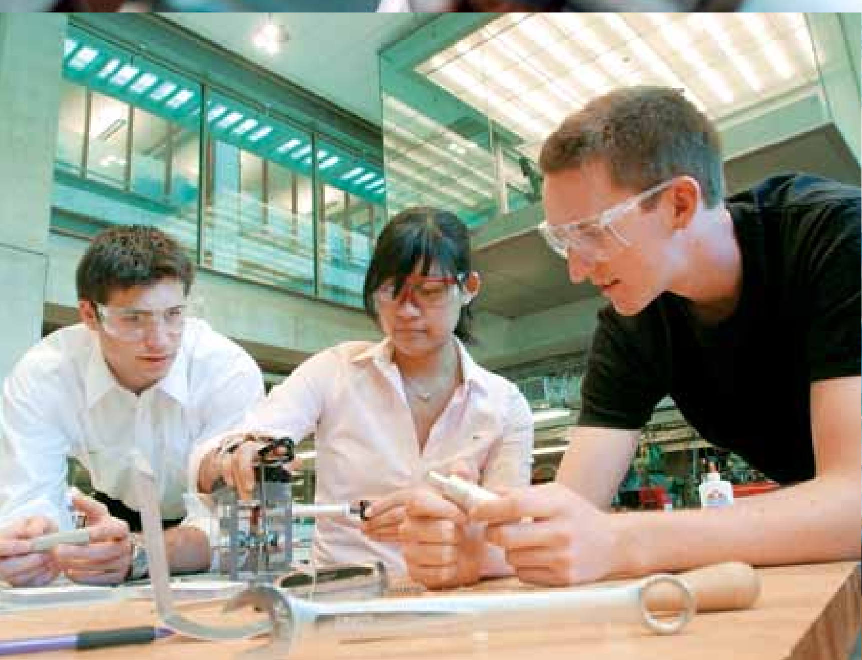
Notice something different about the photos at the opening of this series of articles (page 22)? The artistic blending of the images is the result of an image processing algorithm developed by **Thrasos Pappas** (above), associate professor of electrical engineering and computer science. Pappas was an early pioneer in the field, and he developed this algorithm for computer image analysis in the early 1990s.

While humans can see and understand images quite easily, it's an altogether different story for computers, which analyze everything in terms of numbers. So image processing researchers have developed new ways for computers to segment an image that make it easier for a computer to comprehend. One such approach is called adaptive clustering.

Pappas's algorithm segments an image into areas of uniform color. The algorithm is adaptive, meaning it allows color gradation within segments that are separated by sharp color transitions, which typically occur at object or illumination boundaries. The result is an almost painterly treatment, smoothing out noise while preserving important edges in the photograph.

If a computer can analyze an image, understand its content, and perform a task based on that understanding, it can also execute automatic jobs like processing and labeling images or searching medical images for tumors, or even autonomously navigating a car. Pappas has extended his algorithm to video and image texture analysis, and he is currently working on color-texture video segmentation, which could be useful in motion-sensor surveillance cameras. "It just also happens to create these images with a pleasing artistic effect," he says. ■

EDUCATION FOR



While McCormick's researchers work to solve today's most pressing problems, McCormick's faculty, administration, student services, and student groups aim to develop the leaders of tomorrow. Through an evolving curriculum, growing personal and professional development initiatives, and motivated groups, McCormick and its students continue to prepare for the future.

THE FUTURE

DESIGNING A NEW CURRICULUM

In the late 1990s, the notions of design and design thinking — concepts that drive much of McCormick's vision today — inspired creation of a new kind of curriculum: Engineering First. At the time, Dean Jerome Cohen and Steve Carr, associate dean for undergraduate engineering, saw that many first-year students were frustrated by the standard concept-based freshman curriculum. Students wanted to put what they were learning into action. Additionally, Cohen and Carr wanted the McCormick curriculum to anticipate the global marketplace that awaited graduates.

"What I saw going on in our curriculum was admirable, very challenging, and led by world leaders in their fields," Carr says. "But I didn't see how that was going to produce a kind of culture that gave birth to one industry after another and leaders for those industries — providing all of the economic benefits that come with that, as well as products that advance civilization."

So Cohen and Carr asked Ted Belytschko, Walter P. Murphy Professor in mechanical engineering, to lead a group of faculty in rethinking the way the school educated engineers. The committee revised the first-year curriculum to include two complementary sequences: Engineering Analysis (EA) and Engineering Design and Communication (EDC). In EA students learn the analytical framework that supports their further study in engineering. In EDC students put that framework to use: it requires teams of first-year students to work together to create a design that addresses a challenge presented by a client in the community. Doing so, they apply techniques learned in other classes. EDC also teaches students communication skills, including sketching, writing, and presenting, as they learn how to communicate with clients, with their team members, and with other audiences. The EDC sequence — developed by a team led by Ed Colgate, professor of mechanical engineering, and Penny Hirsch, professor of instruction in writing in Weinberg College's Writing Program — quickly became a hallmark of the McCormick approach to engineering education.

"The most important, and hopefully enduring, lessons are those that have to do with understanding how to approach an unstructured problem," Colgate says. "It's being sure that you understand what the real problems are and ensuring that they are the ones you're solving."

Engineering First served as the beginning of a larger cultural change at McCormick, in which design was incorporated into many different programs across the school. Soon departments integrated design projects into their capstone courses, faculty developed entirely new design courses, and students created new groups focused on design. "Before Engineering First, the only courses that had 'design' in the title were computer-aided design courses," says Carr. "Our courses didn't focus enough on the big-picture, intellectual pursuit of design."

Carr notes that this emphasis has improved many of the standard courses in traditional engineering areas. One example he often cites to prospective students and parents is the introductory course in electrical engineering. "Many people remember the circuit analysis courses," Carr says. "Students rarely liked it. It was a slog through differential equations and Kirchhoff's law, yet at the end of the term students actually do a lot to apply these concepts. The electrical engineering program addressed the problem by creating a course that was a design challenge that covered everything students need to know. Now students like it, and they learn even more than before because they are motivated to complete their projects."

Design projects have been so successful that in 2002 the Margaret and Muir Frey Prize was established by Donald Frey, professor of industrial engineering and management sciences, to recognize student work in their capstone courses. The projects nominated for the prize — ranging from health products geared for the developing world to innovative robotics — are a testament to the design education students receive at McCormick.

Top left Ed Colgate, Steve Carr, Penny Hirsch, and Ted Belytschko
Left Students in the Engineering Design and Communication sequence

PREPARING STUDENTS

Design curriculum and programs have expanded at the graduate level as well. Don Norman, Breed Professor of Design, professor of electrical engineering and computer science, and codirector of the Segal Design Institute, has led the development of a design track within the MMM Program, McCormick's joint master's degree program with the Kellogg School of Management. The Master of Science in Engineering Design and Innovation Program, led by Ed Colgate, was launched in 2008 following the establishment of the Segal Design Institute. The Master of Product Development Program, led by Walter Herbst, clinical professor of mechanical engineering, and Richard Lueptow, professor of mechanical engineering and senior associate dean for operations and research, rounds out McCormick's graduate offerings in design.

These programs have seen early success, highlighted by a recent nationwide design competition sponsored by DiabetesMine.com, a web site devoted to providing solutions for people living with diabetes. Eric Schickli, a graduate student in the Master of Science in Engineering Design and Innovation Program, and Samantha Katz, a graduate student in the MMM program, won the top prize in the competition, which attracted more than 150 entries from many of the top schools in the nation. Schickli and Katz's project was the LifeCase and LifeApp system, which combines a lancer, test strips, a glucose meter, wireless insulin pump management, and disease management software for the iPhone into one package. Schickli says the design community at Northwestern fosters the kind of design thinking needed to create such innovative solutions. "McCormick students attack real-world problems and come up with winning solutions," he says.

While design has become a dominant theme over the past decade, McCormick continues to develop new programs to take the school into the future. The Farley Center for Entrepreneurship and Innovation has bolstered the number of courses in entrepreneurship for both undergraduate and graduate students and is leading collaborations among Northwestern's schools. McCormick also recently launched a program in architectural design and engineering, and faculty continue to develop new courses in emerging research areas. The goal of all of this activity is simple but profound: to ensure that McCormick students are prepared to have maximum impact in their careers. Feedback from recent alumni shows that the school is on the right track.

Mike Hoaglin (biomedical engineering, electrical engineering '06) participated in the study abroad program in global health technologies, in which students work on design problems relating to global health and study the environments in which their solutions are used. Now in medical school after two years of consulting, Hoaglin is confident that McCormick prepared him for success. "I realize that many of my colleagues are very good at memorizing and regurgitating details on the exams," Hoaglin says. "I am more of an integrator, problem solver, and critical thinker. That's what my engineering experience taught me." — Kyle Delaney

When it was created 70 years ago, McCormick's cooperative education program was a revolutionary idea: students could learn both in school and on the job. Now the McCormick administration is working to transform career development again, expanding options and making sure students are prepared for ever-changing careers.

In the 1930s industrialist Walter P. Murphy decided to fulfill his life's ambition of spending his wealth "in the creation of a great institution of human service." He considered hospitals and universities, but the more he thought about it, the more he wanted to use the money to promote industry through education. His lawyer sent an anonymous letter to several schools, seeking out information on their engineering programs. Northwestern's plan for a new building and educational program impressed him the most.

More than $34 million later — an initial donation of $6 million followed by $28 million several years later, after Murphy's death — Northwestern had a new Technological Institute building and a new program, the Walter P. Murphy Cooperative Engineering Education Program. The program would give students the chance to alternate periods of academic study with periods of full-time paid work experience — an experience Murphy held in high regard.

"This cooperative system appealed strongly to me as truly American," Murphy wrote in a letter to the Northwestern Board of Trustees that was placed in the cornerstone of Tech. The program combines "the highest type of classroom instruction in theory with synchronized and coordinated training in the actual workshops of highest type cooperative industries in the practical application of theory so taught in the classroom," Murphy wrote.

Seventy years later, the program is still going strong. More than 30 percent of McCormick students participate in the program and spend up to six quarters at one of about 200 participating employers. Recently, however, McCormick administrators decided that the co-op program alone wasn't enough for students. "We wanted to help students be prepared to leave McCormick and be nimble and flexible enough not only to view

Left **Joe Holtgreive and Helen Oloroso**
Bottom left **Fuko Tsuruta at the Rise Group during her co-op experience**
Bottom right **Jonathan Bragg works during a summer internship with PepsiCo in logistics**
Below right **Claudia Villamil participates in co-op at Abbott Laboratories**

life as an extension of engineering but to think about how personal development influences career development, and vice versa," says Helen Oloroso, assistant dean and director of the newly named McCormick Office of Career Development.

So a new initiative was born. As part of this effort, McCormick is expanding its career development programs, as well as offering new ways for students to look at how their personal development can

FOR SUCCESS

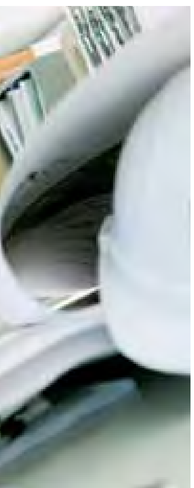
grow with their education. These new initiatives, which senior administrators began planning in 2006 and which are now being implemented, aim to both offer new career development courses and internship opportunities and facilitate group discussions that ask the big questions — like, Who am I? and Where am I going?

The first task in transforming career development was to formalize internship availability. Previously students could find internship listings only through University Career Services. Now, McCormick offers students access to a database of internship opportunities that enable them to work in a position related to their major without taking time off school (a requirement in the co-op program).

The next step was to create the course Introduction to Career Development, which is now a requirement for students who want to participate in an internship or in the co-op program. That course, taught by industry professionals with MBAs and backgrounds in engineering or human resources, includes three major components: how to decide on a career, how to develop tangible skills (like creating a résumé and networking), and what to expect from the transition from school to work. More than 240 students have taken the course so far.

"By creating this course, we can assure there will be consistency," Oloroso says. "We want our students to have a knowledge base they can build on. Before this course existed, we held workshops — which people couldn't always attend — or one-on-one sessions, which were too time-consuming."

In these uncertain economic times, career development is more important than ever. Employers have cut back on hiring, and many parents have found that money set aside for school won't cover expenses. While University Career Services will still coordinate senior recruiting, McCormick students now have the opportunity to be better prepared when they reach that point. "This career development model isn't new. We've always tried to get students to think about these issues," Oloroso says. "We're just keying them into something



that gives them more opportunities. By taking advantage of these opportunities, students will have a leg up in the marketplace."

The new initiative doesn't stop with careers. That's where Joe Holtgreive, assistant dean of student development, comes in. "As we thought about what it means to prepare for a career, we acknowledged that the challenges facing our current graduates are unprecedented in size and scope," he says. "To enable them to face these challenges we need to prepare them to take a whole-brain approach to engineering. We wanted to empower them to grow personally as they grow intellectually."

To that end, McCormick has begun offering a pilot personal development program for a subset of first-year students. As part of the program, five first-year faculty advisers also served as "college coaches" who helped facilitate quarterly group meetings with students. These meetings focused on students' self-awareness (through the use of a self-assessment tool) and fostered discussions on issues like cocurricular options and why students chose to study engineering at Northwestern. "We want our students to develop a strong sense of community and an awareness of the vast opportunities available to them," Holtgreive says. "We also want to provide them an opportunity to reflect on their experiences to learn about themselves and the world around them in the process."

There are plans to present alumni speakers and a new online portfolio tool as the personal development program is expanded to include upperclass students. So far student reaction has been positive.

"It's really nice to talk about how college can mesh with life so easily," says Ryan Sanders (civil engineering '12) "When you are around other people going through the exact same thing and you have time to talk about it, it opens a flow of ideas that each person can use."

For Andrea Morgan (environmental engineering '12) the program has been an avenue not just to discuss personal development but also to speak directly with the McCormick administration. "I was excited when I found out I was a part of this pilot group. I felt it would give me a great opportunity to meet important people on campus. How often do you get to sit down with an assistant dean, the co-op director, and your adviser?" she says. "It's been really useful to have this contact, especially as a freshman, when I'm still deciding if co-op is something I want to do. It has proven invaluable."

While co-op remains the cornerstone of industry education at McCormick, this new initiative supports Walter P. Murphy's desire — expressed in his will — that Northwestern's engineering school be "second to none in America." — **Emily Ayshford**

STUDENT GROUPS

Whether they are promoting engineering to teenagers, laying pipe in Central America, or communicating with the administration, student groups play an integral role at McCormick. These groups have evolved to form a new class of leaders who push students toward two goals: leading their peers and making a difference in the world. It's a trend that puts McCormick and its students at the forefront of engineering and community service.

The largest student groups at McCormick are also the oldest. As engineering schools have grown and become more diverse over the past 30 years, several organizations have been formed to foster leadership and support among underrepresented groups. The Society of Women Engineers and the National Society of Black Engineers (NSBE) have been part of McCormick since the mid-1970s. The Northwestern chapter of the Society of Hispanic Professional Engineers (SHPE) was formed in 1992. Together these groups have provided a support system and professional guidance for thousands of students — and they have grown to be important community servants as well.

The Society of Women Engineers hosts annual outreach events that show teenage girls what it means to be engineers. NSBE and SHPE host a design competition for minority students from local high schools along with lectures by Northwestern professors. SHPE tutors elementary and middle school students.

"NSBE and SHPE's involvement in the community is essential for fueling the pipeline of minority engineering," says NSBE president Evan Dickerson-Rusan (mechanical engineering '11). "I believe that these attempts to foster interest in engineering in high school students are successful, because I am a product of their efforts." While these organizations remain a strong presence on campus, new groups have sprouted to serve the community. The McCormick Graduate Leadership Council began in 2006 as a way to promote community among the hundreds of graduate students scattered across the school's departments. Many of these students found that they spent so much time in the lab that they didn't know their colleagues and didn't have a chance to relax with friends. Couple this with the need for a graduate student voice within the administration, and the mission of the graduate student council was clear. Now the group, led by civil engineering graduate student Steven Greene, holds social events, provides networking opportunities, and meets regularly with the administration.

"Meeting new graduate students can feed back into your work. And being a conduit to the administration gives us a chance to give them our perspective," says Alok Tayi, a graduate student in materials science and engineering and former cochair with biomedical engineering graduate student Carrie Brubaker.

The McCormick Student Advisory Board was formed around the same time with the same goals at the undergraduate level. The group has created a peer mentoring program to help new students with everything from classes to the co-op program. "We're dedicated to representing the student body and working with the administration to address our needs," says board president Michael Leaf (chemical engineering '11). "I've had a lot of opportunities here; I want to help other students find new opportunities so they can look back on their McCormick experience as positively as I do."

Many of the student groups that have formed over the past several years have missions that aim to help the community and make a difference in the world. Engineers for a Sustainable World (ESW), a national nonprofit network, came to Northwestern in 2002 and has already seen success. The group has installed solar-panel systems on roofs in an off-the-grid town in Panama and improved wastewater treatment in another Panama town and is now working to convert animal manure into methane gas for cooking and lighting in Nicaragua. Locally ESW has converted a University shuttle bus to run on waste vegetable oil from campus cafeterias, and they've created programs to teach sixth-grade science classes about sustainability.

The Northwestern branch of Global Water Brigades has also worked in Central America. An organization of students and volunteers from around the world dedicated to improving access to clean water and sanitation, the group came to McCormick in 2008. Eight Northwestern students have already traveled to Honduras to study water systems, meet with engineers and technicians to discuss water development, and plan for future volunteer trips. In the town of Los Pajarillos students have helped dig trenches and lay pipe for a new water line.

While some student groups cross continents, others aim to help out in Northwestern's backyard. Students Consulting

Top **Design For America brainstorms during a group meeting.**

Right, clockwise from top **Members of Engineers for a Sustainable World working in Central America; members of the Society of Hispanic Professional Engineers; a member of the Society of Women Engineers at an outreach event for girls**

LEAD THROUGH SERVICE

for Nonprofit Organizations offers strategic consulting to local community organizations. The group was formed in fall 2008 and took on its first project last winter, creating a plan for a teen center in Winnetka that wanted to attract more young people. The group worked on three projects in spring 2009 and continues to take applications from nonprofits who need help with marketing, fundraising, organization strategy, and operational management. "This is a great way to help the community," says Saad Shahab (industrial engineering and economics '10), founder and president of the group. "It's another way to take what you've learned in class and apply it to strategic problems."

Helping the community is also the purview of Design for America, a student group advised by Liz Gerber, assistant professor of mechanical engineering. Gerber wanted to rally the energy of undergraduate students and create a design-focused program similar to Teach for America, so she and Dean Julio M. Ottino held a meeting to see if there was any interest. "I got an e-mail that said, 'Do you like design, and do you like helping people?'" says Mert Iseri (industrial engineering '11), a member of the group. "The moment I saw that, I was touched. It just sounded so cool. It's just something really fun and really cool."

Several dozen other students thought so, too, and within a few months the group had won an award in a design competition: the DiabetesMine.com challenge, which asked teams to create new tools for improving life with diabetes. The Design for America team created Jerry, the Bear with Diabetes, an interactive stuffed toy and web-based play space for children with diabetes. The team won the award for the most creative entry, which came with a $5,000 prize. Now the team is trying to figure out how to make the project a reality.

With the help of Gerber and Katy Mess, a McCormick consultant, McCormick's Design for America group also created a summer fellowship program involving three projects: how to improve hand washing in hospitals, how to improve wellness in the face of a youth obesity epidemic, and how to design an organization that offers crime prevention counseling to children in high-crime areas. "We're helping them redesign their operations so they can attract more young people and make sure they stay with the program," says member Yuri Malina, a student in Weinberg College.

Members of Design for America hope to expand their work — and they hope Design for America spreads across the United States. "Just as the San Francisco area is an IT center, I want Northwestern to be a center for social entrepreneurship," Iseri says. "People helping other people with their skills, design, and creativity. We have so much talent here, and students need something more to do than just their homework. They can design for their next-door neighbors."

No matter what their purpose, these student groups offer what students often need most: a sense of community at McCormick. "Student organizations can help to build a real sense of pride among students," says Ellen Worsdall, assistant dean for student affairs. "Students who get involved become a part of a community and learn leadership skills. Both are invaluable assets that they'll have for the rest of their lives." — **Emily Ayshford**

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3M Company
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The V Foundation
The Estate of Ernest H. Volwiler and Lillian H. Volwiler
Robert P. Wayman ’67, MBA ’69, and Susan H. Wayman
The Whitaker Foundation
William J. White ’61 and Jane Schulte White

In memoriam

Richard L. Parkin ’41
William Thomas Armstrong ’42
Jerry R. Horak ’43
Raymond E. Cross ’44
William F. Liddell ’44
Lucius Cole Jr. ’45
Joseph C. White ’45
Gale R. Billard ’46
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Carl R. Norlander ’49
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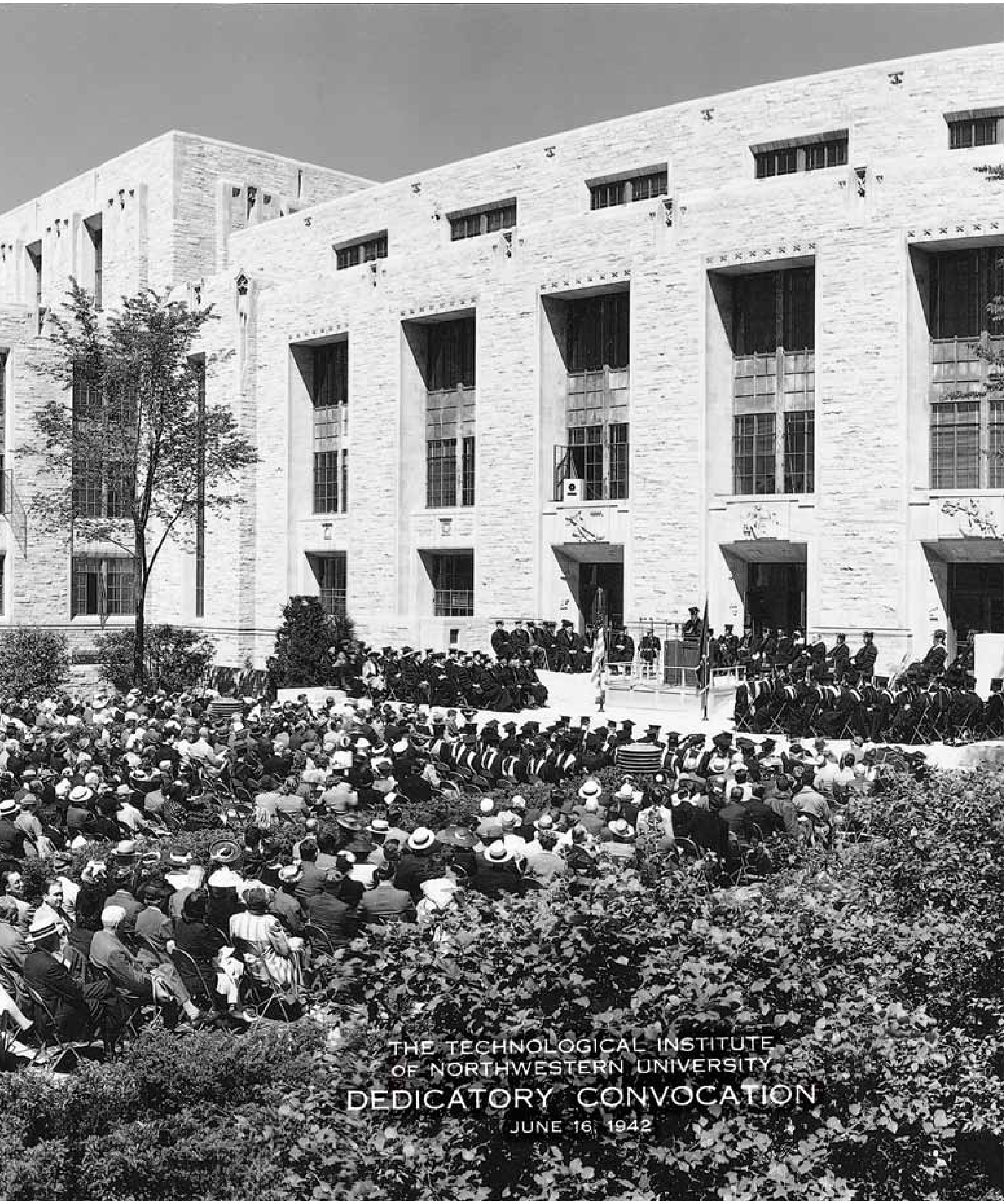
Thomas E. Collum ’75
Robert J. Sullivan ’80
Bertina Y. Gillis ’81
Marlanda English ’83
Richard K. Harris ’01

Theodore Van Zelst, a life member of the McCormick Advisory Council and longtime supporter of McCormick and Northwestern, passed away on July 6. Van Zelst earned bachelor’s and master’s degrees in civil engineering from Northwestern in 1945 and 1948, respectively, and went on to cofound Soiltest, which became the world’s largest provider of construction materials testing equipment with sales in more than 150 countries. His accomplishments include developing the swing-wing for supersonic aircraft and producing the first mobile X-ray baggage inspection unit. He held several patents for soils instruments and was most recently president of Testing Sciences in Glenview, Illinois. He also served as an officer and director of the International Road Federation for more than 50 years. Van Zelst served on the McCormick Advisory Council from 1983 until his death. In 1988 the Northwestern Alumni Association awarded him the Alumni Medal — the highest honor given to a Northwestern alumnus. Earlier he had received the Alumni Service Award and Merit Award; he was one of six people in the history of the University who earned all three Northwestern alumni awards.

FROM THE ARCHIVES

1942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