McCormick School of Engineering and Applied Science

NORTHWESTERN ENGINEERING

SPRING 2015

EMBRACING A COMPLEX WORLD

SCIENTISTS AND ENGINEERS WORK TO UNDERSTAND THE BEHAVIORS OF COMPLEX SYSTEMS

A NEW TWIST ON AN OLD GAME

Students in the Master of Science in Engineering Design and Innovation program designed a new take on the classic game Twister. Developed in their Designing Product Interactions course, the game incorporates visual, auditory, tactile, and emotional inputs into a delightful new interactive experience. Brad Gill, Kamyin Cheng, and Daniela Garzon (all not pictured) displayed their game at the fall Segal Design Expo, where visitors got in on the fun.


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JOIN THE
Agricultural
REVOLUTION

"One of the most important skills we want to impart is the ability to dissect problems to their essence, to understand the real problem behind a perceived problem."

JULIO M. OTTINO DEAN OF THE MCCORMICK SCHOOL

GREETINGS FROM MCCORMICK

At McCormick, we pride ourselves on educating engineers with thinking skills that differentiate themselves from their peers. Among these are the ability to link divergent and convergent thinking, to work across boundaries, and to bring creative approaches to their work. One of the most important skills we want to impart is the ability to dissect problems to their essence, to understand the real problem behind a perceived problem. This ability to see simplicity amidst complexity is a critical competency.

Yet it isn't enough. To be successful, our students must also be able to see complexity in simplicity, to understand the many ramifications and consequences of each decision or solution. This requires an understanding of connectivity and interrelationships, which we cover in this issue of *Northwestern Engineering*.

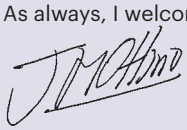
Complex systems, which I have studied for many years, are those that have no central organizing principle; rather these systems are composed of collections of agents that connect and give rise to something entirely new. The whole is greater than the sum of its parts; we cannot understand the system simply by deconstructing it.

With new access to vast networks of data, we have the opportunity to use and develop the toolkits of complexity research to understand how subtle relationships and actions drive systems, how they react to input, and how they can fail. The research provides insights into understanding and managing the complex systems that affect our everyday lives, such as the environment, the Internet, processes within cells, and our social networks. This growing, highly interdisciplinary area of research is a significant strength for Northwestern.

We also highlight how many of our students expanded their thinking through collaborative courses with the School of the Art Institute of Chicago and the Department of Art Theory and Practice at Northwestern. These courses provide an enriching clash of cultures. Interdisciplinary teams are challenged to create art—both to exhibit and to effect social change. The results have been fascinating.

Our Q&A this issue features Stephen Carr, our senior associate dean of undergraduate engineering. Steve has held that role for 23 years and has been a key contributor to many changes at McCormick. When he steps down from this position in June, he can do so with pride. He has guided generations of our students on their paths and helped modernize our educational initiatives. I want to thank him for his efforts that have shaped the school and for his erudite presence among our leadership.

As always, I welcome your feedback.



Julio M. Ottino
Dean, McCormick School of Engineering and Applied Science

On the Cover

A subset of BitTorrent's peer-to-peer filing sharing activity during one day in March 2009. Each line represents one user downloading a file from another, and the color indicates the type of file shared.

Read more on page 14.

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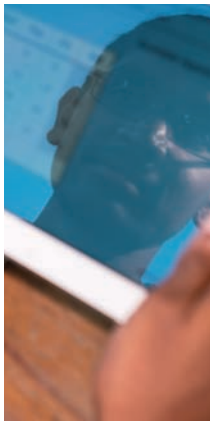

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NORTHWESTERN ENGINEERING
SPRING 2015

NEWS

"Conversations at the Intersection" Explores Nature of Creativity

New in 2014, the McCormick series "Conversations at the Intersection" provided broad audiences a glimpse into the creative process across disciplines, inspiring ongoing discussion about the differences and similarities of creative fields. Two sessions featured panels of intellectual leaders from different backgrounds who discussed, debated, and explored what art, science, and technology can teach us about insights and creative process.

The first panel featured structural engineer Bill Baker, humanities professor Saul Morson, and Dean Julio M. Ottino. The trio discussed epiphanies, constraints, and the relationship between creativity and age. "I don't believe in epiphanies," Ottino said. "Usually there are a lot of pieces to the puzzle. The final piece is only different from the other pieces because it's the last one."

The second panel featured architect Larry Booth, philosophy professor Sandy Goldberg, and artist Jeanne Dunning. They discussed facets of creativity, including ways to overcome creative blocks, the concept of a "lone genius," and the underlying process of creative works. "You have to go through the world being open to the thing that will fulfill your desire," Dunning said. "It's going to come to you in some form that you never would have imagined. Creativity is being open to the connections between things."

"CREATIVITY IS BEING OPEN TO THE CONNECTIONS BETWEEN THINGS."
JEANNE DUNNING

WILDHACKS, NORTHWESTERN'S LARGEST INTERCOLLEGIATE HACKATHON, HITS CAMPUS

In November 2014, more than 400 college students from across the United States piled into the Norris University Center and hacked the night away. The 24-hour Wildhacks hackathon marked Northwestern's largest intercollegiate hackathon to date. Open to students from all colleges and universities, the event challenged teams to create web, desktop, and mobile computer applications. Sponsored by Ford, IBM, and Major League Hacking, the two-day event included participants from Northwestern, University of Wisconsin, University of Michigan, University of Illinois, and Johns Hopkins University.

Michael Marasco, director of the Farley Center for Entrepreneurship and Innovation, was inspired by the spirited collaborations. "It was beyond my expectations," he said. "Seeing students work in small teams but also collaborate across teams was very special."

Eighty-six teams submitted projects, which judges scored based on four criteria: originality, technicality, design, and usefulness. Northwestern's Michael Wang took first place with "BikeSight," an app that uses a Myo armband to sense hand gestures to operate light-up icons on the biker's helmet that improve visibility and safety.

"The goal of Wildhacks wasn't to try to build the next Facebook but to promote hacking culture," said Suzee Han (WCAS '15), who helped plan the event. "We wanted to connect hackers with each other and give them the time and resources to do what they love."

ENGINEERING STUDENT AWARDED CHURCHILL SCHOLARSHIP

McCormick senior Edward Pang received a Churchill Scholarship from the Winston Churchill Foundation to pursue graduate studies at the University of Cambridge. Driven by a devotion to sustainability and a lifelong love of airplanes, Pang is excited to work to improve the energy efficiency of future aircraft through innovative new materials. Pang will be based in the materials science and metallurgy department at Cambridge to work toward a research-based master's degree. He will focus on a new family of titanium-based shape-memory alloys, which promise substantial efficiency improvements in gas turbine engines.

ADVANCED DEGREES CONFERRED IN FIRST DECEMBER COMMENCEMENT

McCormick celebrated the graduation of 120 master's degree students and 13 PhD students during its first-ever December ceremony. The event featured IBM's Brenda Dietrich, who talked about how data and access to information have changed since she earned her PhD in 1984.

MEETING FUTURE SCIENTIFIC COMPUTING NEEDS

Financial engineering is integral to solving complex problems in the financial sector. But future breakthroughs will require new, higher-performing computing resources. To help meet these needs and accelerate innovations, Intel® has named McCormick as one of its Intel Parallel Computing Centers. With this support and funding, research at the new center will use high-performance parallel computing for solving financial problems.

Transportation Center Turns 60

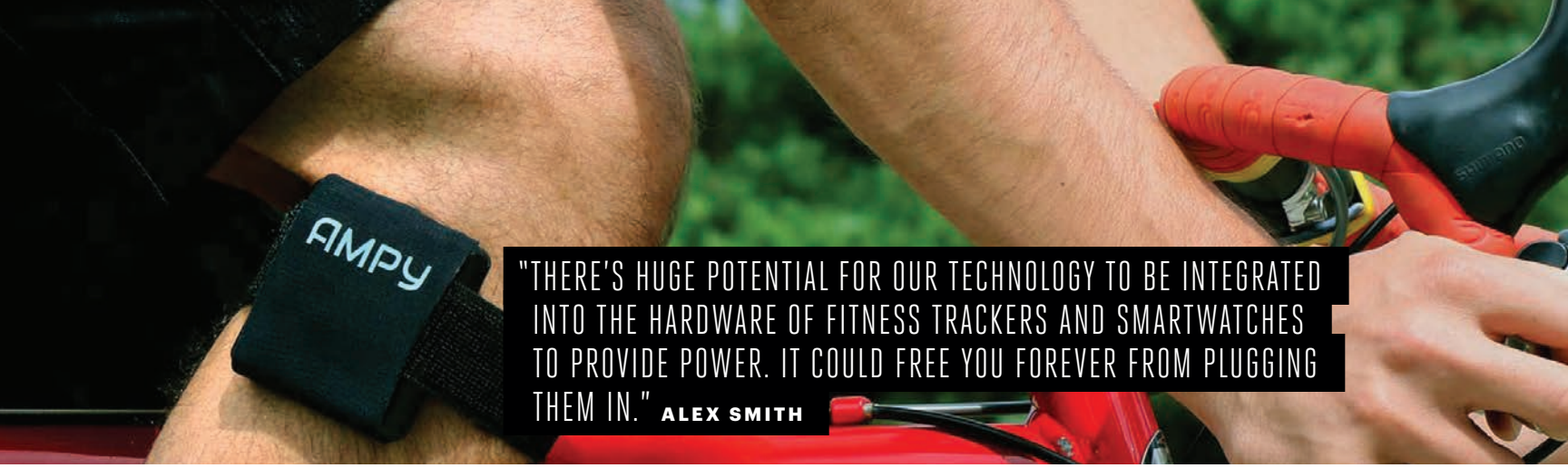
The Northwestern University Transportation Center celebrated its 60th year in November with a gathering of industry insiders in Evanston to discuss the transportation landscape's major challenges and opportunities. The celebration featured keynote speaker Gwynne Shotwell ('86, MS '88), president and COO of SpaceX. She shared videos of the company's rocket launches and discussed plans to put the first people on Mars, a feat that she predicts will happen within 15 years. She told an audience of faculty, alumni, and friends to think about the trip to Mars like the Westward Expansion of the 19th century: it will take many months, but it will be worth it. Expert panels also explored the future of transportation in the United States from a range of perspectives, including supply chain, sustainability, finance, and innovation.

ALUMNA CEO ELECTED TO PRESTIGIOUS ACADEMY

IBM CEO Virginia M. Rometty ('79) has been elected to the National Academy of Engineering, one of the highest professional distinctions accorded to an engineer. She is cited for strategic applications of systems engineering and leadership in the development of service science—a strategic area of study that aims to help service-based economies innovate, manage, evaluate, and optimize their businesses—and its application to business processes.

"IT WILL BE IMPORTANT TO BE ABLE TO MOVE HUMANITY TO ANOTHER LOCATION IN CASE SOMETHING TERRIBLE HAPPENS ON EARTH."

GWYNNE SHOTWELL
PRESIDENT AND COO OF SPACEX



"THERE'S HUGE POTENTIAL FOR OUR TECHNOLOGY TO BE INTEGRATED INTO THE HARDWARE OF FITNESS TRACKERS AND SMARTWATCHES TO PROVIDE POWER. IT COULD FREE YOU FOREVER FROM PLUGGING THEM IN." **ALEX SMITH**

Student Startup AMPY a Power Move

Imagine charging your smartphone by taking a walk around the block. Now you can with AMPY, a handheld device that captures kinetic energy as you move and then converts that energy into an electric charge. McCormick PhD students Michael Geier, Tejas Shastry, and Alex Smith developed AMPY during the winter 2013 session of NUvention: Energy, a course that brings together students from across Northwestern to build products and services in the sustainable energy field. The device has already garnered major funding and media buzz, including coverage by *Forbes*, *Crain's Chicago Business*, *USA Today*, and *BuzzFeed*. Smith also appeared on Fox Business and CNBC, where viewers voted AMPY as the Tech Crowd leader of the week.

At half the size of a modern smartphone, AMPY can fit in your pocket or easily strap onto your arm or leg to collect energy as you walk, run, cycle, or simply fidget. It works with patent-pending, proprietary inductor technology that generates electricity to charge an internal battery. AMPY can store a week's worth of energy, which can then be used to charge any device with a USB port. A 30-minute run, for example, can give a smartphone a three-hour charge or a smartwatch a 24-hour charge.

AMPY has been a favorite on the startup circuit, winning a total of $100,000 in competitions. The team also won a 2014 Proto Labs Cool Idea! Award, which funded prototype production for pilot testing. During a run on Kickstarter last fall, the team received more than $300,000, exceeding its goal by 300 percent.

SENIOR RYAN DEBLOCK NAMED CO-OP STUDENT OF THE YEAR

Materials science senior Ryan DeBlock was selected McCormick's 2015 Walter P. Murphy Cooperative Engineering Education Student of the Year. He completed co-op and internship programs with Baxter, NASA, and General Electric and plans to attend graduate school next year.

97%

Amount of light absorbed by professor Koray Aydin's new color filter, which can transform silver into any color of the rainbow.

23,000

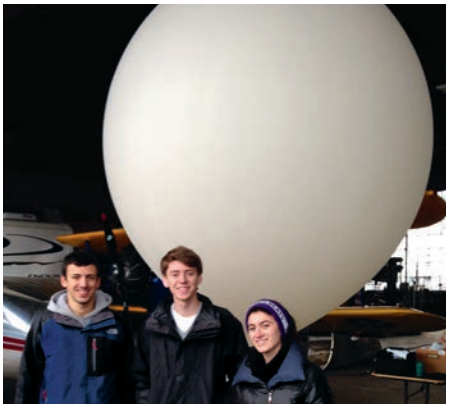
Number of scientific articles that professor Luis Amaral's new big data algorithm separated with high accuracy and reproducibility.

FACULTY PANEL IMAGINES THE "FUTURE OF WORK"

Five faculty members came together in October 2014 to discuss how technology will change the workplace. Moderated by McCormick Dean Julio M. Ottino, "The Future of Work" featured Northwestern professors Kristian Hammond, Larry Birnbaum, Malcolm MacIver, and Joel Mokyr. Members of the panel agreed that, contrary to outside opinions, technology will not damage the economy by replacing human workers. Mokyr, a professor of history and economics, said that innovation will continue as long as "low-hanging fruit" remains to be picked. "There are far more fruits on this tree than the eye can see," he said. "All we have to do is build taller ladders. That is precisely what scientists are doing for us."

TAFLOVE INTERVIEWED IN *NATURE PHOTONICS*

In the January 2015 issue of *Nature Photonics*, Allen Taflove discussed the impact and importance of James Clerk Maxwell's equations for electromagnetic radiation. Known as the father of finite-difference time-domain techniques, Taflove's interview is one of several articles in the journal celebrating the 150th anniversary of Maxwell's equations and the importance of optics. A professor of electrical engineering and computer science, Taflove shared insights into how the equations influenced his career.



STUDENTS LAUNCH WEATHER BALLOON

Six students, including five from McCormick, achieved their second high-altitude weather balloon launch in November 2014. As members of the Northwestern University Space Technology and Rocketry Society, they designed and manufactured the balloon, which reached 98,800 feet above Earth's surface to catch a glimpse of near space. The balloon traveled 111 miles from central Illinois to eastern Indiana, where it came to a smooth landing. Because the balloon was equipped with GoPro cameras, a flight computer, and a GPS system, the team was able to track its entire flight.

2,500

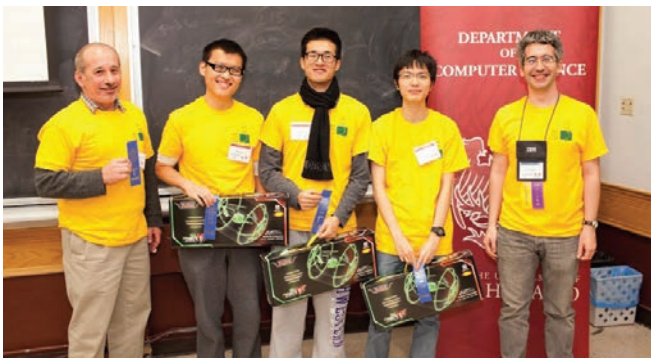
The number of applicants that undergraduate Kevin Chen beat out to land a Kleiner, Perkins, Caufield, and Byers fellowship.

SEMINAR SERIES FEATURES NOBEL LAUREATE

The Dean's Seminar Series welcomed Nobel Laureate Dan Shechtman in October. Shechtman proposed that technological entrepreneurship could be the key to world peace and prosperity. To foster this, he said, we must provide accessible education for all, produce more scientists and engineers, and build a free market system with limited corruption.

PAYPAL COFOUNDER VISITS

Entrepreneur and investor Peter Thiel addressed a packed house at McCormick in December. The PayPal cofounder told students that the ultimate goal for businesses should be to avoid competition and build a monopoly, which is most possible for businesses built on original thinking that can find an unoccupied niche.



NORTHWESTERN WINS PROGRAMMING CONTEST, ADVANCES TO WORLD FINALS

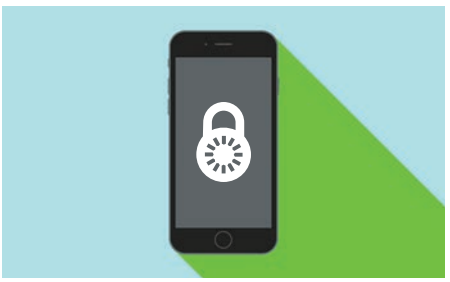
For the second year in a row, a McCormick team has won the Association for Computing Machinery Mid-Central USA Regional Programming Contest. Three undergraduates in electrical engineering and computer science—David Wang, Siyuan Cai, and Edward Kim—made up the victorious Team Mildcat. Sponsored by IBM, the contest challenges teams to solve 8 to 12 programming problems within five hours. Team Mildcat will travel to Morocco for the 2015 world finals in May.

275

Girls who experienced hands-on engineering as part of Career Day for Girls in February.

60%

Amount by which professor Guillermo Ameer's device reduces scarring in damaged blood vessels.



APP LOCKS AND UNLOCKS PHONE

McCormick sophomore William Xiao created an Android app that will banish pocket dials to history forever. Named Pocket Lock, the application smartly locks the phone when you put it in your pocket and unlocks it when you take it out. Within months of its creation, the app was downloaded more than 60,000 times and received positive reviews from technology websites Gizmodo, Digital Spy, and Lifehacker. It is currently free to download from the Google Play Store.

LAB NOTES

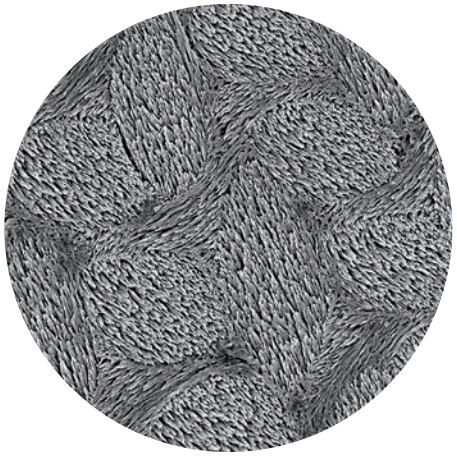
BEAVERS HOLD KEY TO IMPROVING DENTAL HEALTH

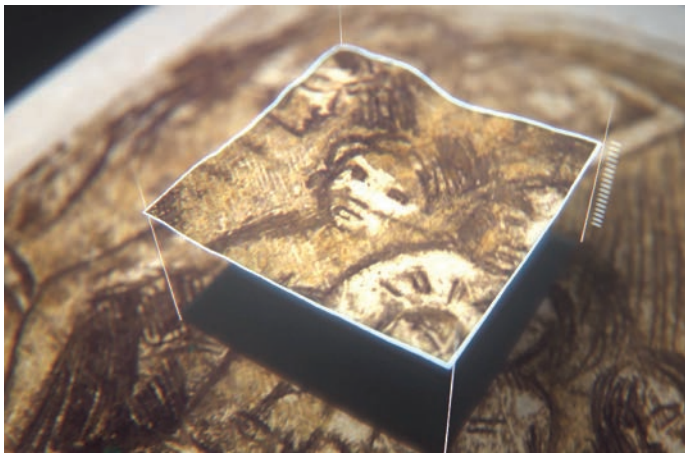
Beavers don't brush their teeth, and they don't drink fluoridated water, but a new McCormick study reports that those dam builders have tooth decay defense built into the chemical structure of their teeth in the form of iron.

A team of researchers led by Derk Joester, associate professor of materials science and engineering, found the pigmented enamel in beavers is both harder and more resistant to acid than regular enamel, including that treated with fluoride. Layers of well-ordered hydroxylapatite "nanowires" form the core structure of enamel. The materials science team discovered that the material surrounding the nanowires contains small amounts of amorphous minerals rich in iron and magnesium and controls the enamel's acid resistance and mechanical properties.

The very complex structure of enamel makes studying it challenging. Joester's team is the first to show unambiguously that this unstructured phase exists in enamel, and the first to show its exact composition and structure. Their discovery could lead to a better understanding of human tooth decay, earlier detection of the disease, and an improvement in fluoride treatments.

"We've made a really big step forward in understanding the composition and structure of enamel—the tooth's protective outer layer—at the smallest length scales," Joester said. "The unstructured material, which makes up only a small fraction of enamel, likely plays a role in tooth decay."





Video Still: Nathan Matsuda

"TO MEASURE THE 3-D SURFACE OF THE PRINTS, WE USED SOME VERY ACCESSIBLE TECHNIQUES THAT CAN BE USED BY ART CONSERVATORS AND HISTORIANS AROUND THE WORLD TO ANALYZE ARTWORKS."

OLIVER S. COSSAIRT

RESEARCH SHEDS NEW LIGHT ON GAUGUIN'S CREATIVE PROCESS

French artist Paul Gauguin, well known for his colorful paintings of Tahitian life, was also a highly experimental printmaker. Little is known, however, about the techniques and materials he used to create his unusual and complex graphic works.

A team from Northwestern and the Art Institute of Chicago used a light bulb, an SLR camera, and computational power to uncover new details of how Gauguin formed, layered, and re-used imagery to make 19 unique graphic works. The team, including McCormick professor Oliver S. Cossairt, studied the 3-D surface of Gauguin's 1902 print *Nativity*. They found that Gauguin placed his paper on an inked surface and then drew on the back of the paper, causing ink to be transferred to the paper where pressure from his pencil was applied. The surface topography research on *Nativity* and other graphic works by the artist will be part of a major Gauguin exhibit at the Art Institute in 2017.

60

Number of companies that recruited Northwestern engineers at the annual Tech Expo career fair.

37%

Percentage of the class of 2018 that is female.

BRINGING TEXTURE TO YOUR TOUCHSCREEN

A research team that includes McCormick professors Ed Colgate and Michael Peshkin reported a discovery that provides insight into how the brain makes sense of data from touch. In a study where people drew their fingers over a flat surface with two "virtual bumps," the team found that, under certain circumstances, the subjects felt only one bump. What's more, the researchers can explain why the brain comes to this conclusion.

Forces transmitted to the fingers as they travel along a flat surface can create the illusion that the surface actually contains bumps. This so-called "virtual bump illusion" is well known in the haptics field, Colgate said, and the researchers were able to make use of it. "By leveraging the virtual bump illusion, we were able to design a meaningful experiment that shed light on the way the brain integrates information from multiple fingers," he said.

"Our findings will help us and other researchers figure out how to design haptic technology to produce certain tactile effects," Peshkin added. The possibilities include flat screen displays featuring active touch-back technology, such as, a touchscreen keyboard that actually feels like a fully dimensional keyboard. Tactile information also could benefit the blind, users of dashboard technology in cars, video game players, and more.

"WE WANT TO CREATE SOMETHING THAT WILL MAKE TOUCH A REALITY FOR PEOPLE INTERACTING WITH THEIR SCREENS, AND THIS WORK IS A STEP IN THAT DIRECTION."

ED COLGATE
PROFESSOR OF DESIGN

AUTOMATED METHOD BEATS CRITICS IN PICKING ENDURING MOVIES

Don't rely on reviews if you want to know whether the movies deemed great today will survive the test of time. A new McCormick study found that the best predictor of a movie's significance is how often it is referenced by other movies. In other words, a movie's significance is decided by other film directors—not critics.

Professor Luis Amaral and his colleagues systematically compared different approaches for estimating a film's significance. They considered metrics for measures both subjective (critical reviews, awards) and objective (citations, box office sales). The researchers found their automated method of movie citations is better at predicting greatness, especially in movies 25 years old or older, than the runners-up: the ratings of movie critics, the number of awards won, and box office sales, among others.

Mind the Gap

James Rondinelli, assistant professor of materials science and engineering, discovered a new way to control the electronic band gap in complex oxide materials without changing the material's overall composition. The finding could lead to better electro-optical devices, such as lasers and new energy-generation and conversion materials, including more absorbent solar cells and the improved conversion of sunlight into chemical fuels through photoelectrocatalysis.

DEMOCRATIZING SYNTHETIC BIOLOGY

Michael Jewett, assistant professor of chemical and biological engineering, and his team pioneered a new protein production method that is faster and cheaper than ever before, making synthetic biology research more accessible for laboratories everywhere—even in high schools.

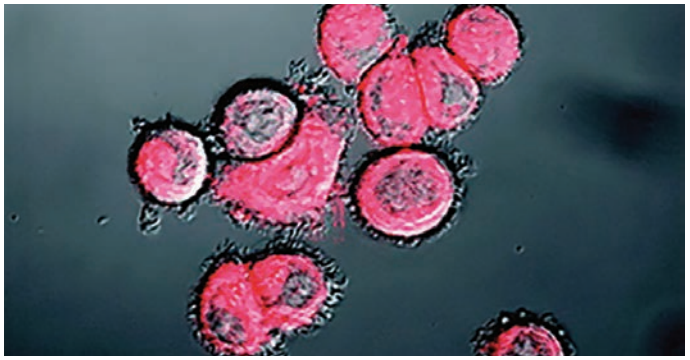
His research addresses a technological gap in cell-free protein synthesis (CFPS), a method of producing proteins without using living, intact organisms. While CFPS bypasses growing proteins in fastidious microorganisms, it requires highly specialized, costly equipment. Jewett's new technique uses common equipment: the standard culture tubes and shake flasks that most labs can afford. Jewett hopes this will allow more researchers to enter the field.

FIRST GENE-BASED TOOL TO DETECT CIRCULATING CANCER CELLS IN BLOOD

Northwestern scientists have demonstrated a powerful tool that can detect cancer cells in the bloodstream long before they settle somewhere in the body and form a tumor. NanoFlare technology is the first gene-based approach for detecting live circulating tumor cells out of the complex matrix that is human blood—no easy feat. In a breast cancer study, the NanoFlares easily entered and lit up the cell if a biomarker target was present, even if only a trace amount.

NanoFlares are tiny spherical nucleic acids with gold nanoparticle cores outfitted with single-stranded DNA "flares." They are designed to recognize a specific genetic code snippet associated with cancer. The core nanoparticle enters cells, and the NanoFlare seeks its target. If the genetic target is present in the cell, the NanoFlare binds to it, and the reporter "flare" is released to produce a fluorescent signal. The researchers can then isolate those cells.

The ability to isolate, culture, and grow the cancer cells will allow researchers to zero in on those cells that matter to the health of the patient. Some circulating tumor cells may not metastasize; analysis of the cancer cells could identify those that will. "This technology has the potential to profoundly change the way breast cancer in particular and cancers in general are both studied and treated," said Professor Chad A. Mirkin, a nanomedicine expert whose lab developed NanoFlares.



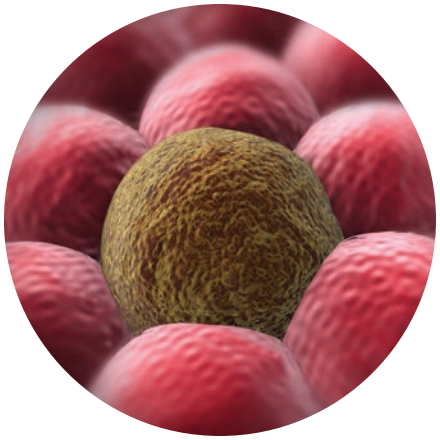
"THIS TECHNOLOGY HAS THE POTENTIAL TO PROFOUNDLY CHANGE THE WAY BREAST CANCER IN PARTICULAR AND CANCERS IN GENERAL ARE BOTH STUDIED AND TREATED." **CHAD MIRKIN**

BLU-RAY DISCS IMPROVE SOLAR CELL PERFORMANCE

McCormick researchers found that Blu-ray discs improve the performance of solar cells—suggesting a second use for unwanted discs. Blu-ray discs, perfected for data storage by engineering over decades, contain a higher density of data than DVDs or CDs. When transferred to the surface of solar cells, this quasi-random pattern provides the right texture to improve the cells' light absorption and performance across a broad spectrum.

IMPROVING MEDICAL SCREENING

Led by Professor Manijeh Razeghi, McCormick researchers have improved stability and lowered the cost of mid- and long-wavelength infrared photodetectors by using new materials and designs. This could lead to cheaper and more effective medical imaging systems that reveal the root causes of a range of conditions, such as headaches, allergies, liver disease, and cancer.

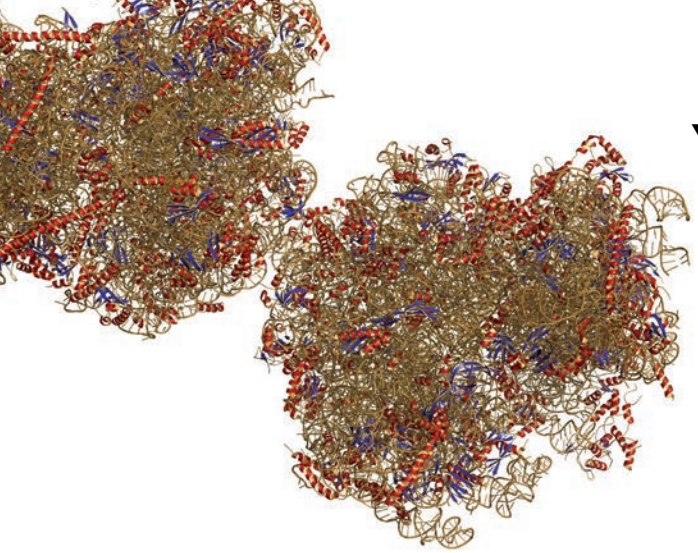


TIPPING THE IMMUNE SYSTEM

In the earliest stages of cancer formation, the immune system will either activate to suppress tumor growth or it will become dysfunctional, helping the tumor grow and making treatment more difficult. Because the tipping point occurs before a patient realizes something is wrong, doctors have been unable to directly observe this critical stage. McCormick professor Josh Leonard and graduate student Danny Wells created a computational model that enables researchers to examine how emerging metastatic tumors interact with the immune system. A better understanding of this sensitive early stage could potentially inform new strategies to overcome immune dysfunction, leading to better outcomes.

99,000

Feet above the earth reached by the Northwestern University Space Technology and Rocketry Society's weather balloon.



Yeast's High-Protein Diet

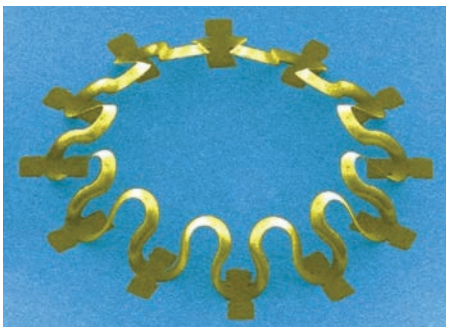
Rapidly-growing and in need of few resources to thrive, yeast has long been a top candidate for mass-producing protein for a variety of products. But the scientific community did not realize that yeast reabsorbs more than half of the protein it secretes. Now Northwestern University's Keith Tyo has found a way to eliminate this problem, enabling researchers to gather more of the protein produced by the yeast. Tyo and his team found the proteins in yeast responsible for the uptake functions and genetically knocked them out. This enabled the team to harvest two- to three-fold more protein from yeast cells than before. The ability to collect more protein product from yeast could lead to cheaper biopharmaceuticals, such as insulin, and biofuels, such as ethanol.

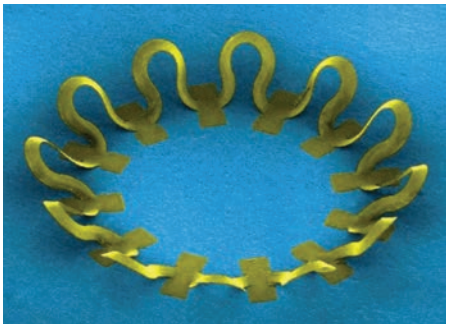
SILVER NANOWIRES DEMONSTRATE UNEXPECTED SELF-HEALING MECHANISM

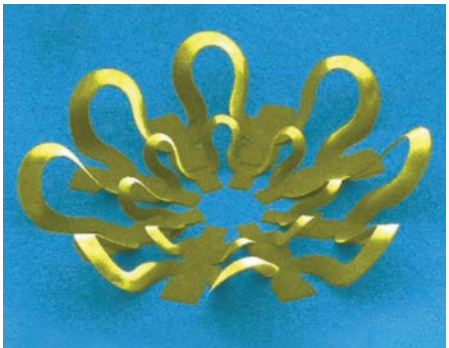
Transparent and conductive, silver nanowires have great electronic potential. But development of the material for use in the electronics industry has stalled because scientists lack a fundamental understanding of its mechanical properties. Now McCormick's Horacio Espinosa has expanded the understanding of the behavior of silver nanowire. His team investigated the material's reaction to stress and found that deformation from stress was partially recoverable, meaning that the nanowire defects self-healed and disappeared.

QUILL CONNECT TELLS YOUR TWITTER STORY

Northwestern startup Narrative Science recently developed a new tool, Quill Connect, that produces personalized reports of your entire Twitter history, comparing it to that of your followers. The report reveals your most tweeted topics and the sentiment of your tweets, and recommends hashtags used by your followers. The tool gives people a view into how they are similar and different from their followers, so they can provide content their followers are more inclined to read and share.







Microscopic Pop-Up Books

Researchers at Northwestern University and the University of Illinois at Urbana–Champaign have developed a simple new fabrication technique to create beautiful, complex 3-D micro- and nanostructures with many advantages over 3-D printing.

The technique mimics the action of a children's pop-up book—starting as a flat two-dimensional structure and popping up into a more complex 3-D structure. Using a variety of advanced materials, including silicon, the researchers produced more than 40 different geometric designs, including shapes resembling a peacock, flower, starburst, table, basket, tent, and starfish.

"In just one shot you get your structure," said McCormick's Yonggang Huang, one of three co-corresponding authors on the study. "We first fabricate a two-dimensional structure on a stretched elastic material. Then we release the tension, and up pops a 3-D structure. The 2-D structure must have some place to go, so it pops up."

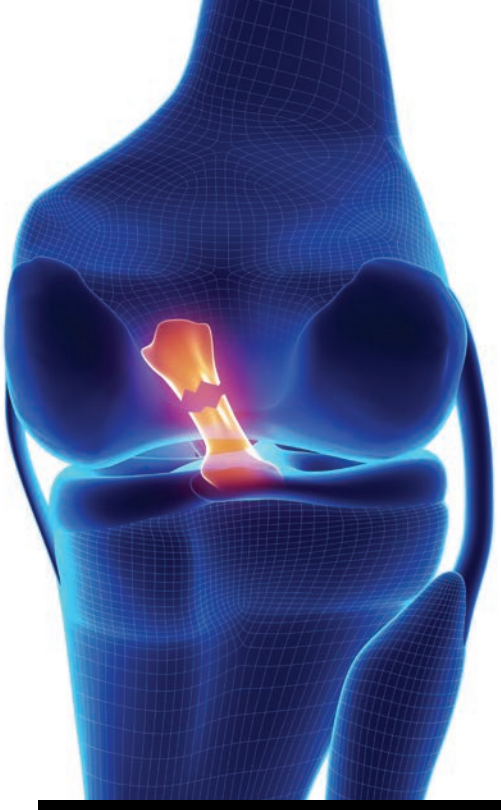
The pop-up assembly technique trumps 3-D printing on many levels and is expected to be useful in building biomedical devices, sensors, and electronics. The technique's advantages are numerous: it's fast, inexpensive, can be used to build many different structures at one time, can use many different materials, and can produce a wide range of different geometries.

$500 MILLION

Worth of the top 10 Farley Center startups

30

Forbes named graduate students Tejas Shastry, Alex Smith, and Mike Geier to its 30 Under 30 Energy list and alumnus Mert Iseri to its list of 30 Under 30 Social Entrepreneurs.



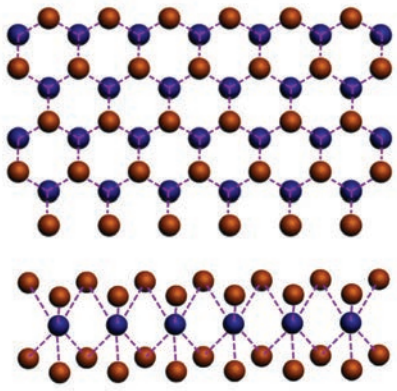
Researchers Engineer ACL Replacements

Guillermo Ameer and his research team are working to engineer an off-the-shelf product to replace damaged anterior cruciate ligaments (ACLs), one of the four main ligaments of the knee. Because the ACL is incapable of healing itself, surgeons rely on autografts for reconstruction. Most common is the bone-patellar tendon-bone graft, in which the surgeon removes part of the patellar tendon to replace the ACL. Many of these grafts cause lifelong pain or even eventually fail. Ameer's approach is to save the patellar tendon to preserve the natural biomechanics of the knee.

Ameer's product comprises three components: an inherently antioxidant and porous biomaterial previously created in his lab, polyester fibers that are braided to increase strength and toughness, and calcium nanocrystals, a mineral naturally found in human teeth and bones. By studying an animal model, Ameer and his team noticed the animal's natural bone and tissue cells migrated into the pores of the artificial ligament, populating it throughout.

"The engineered ligament is biocompatible and can stabilize the knee, allowing the animal to function," said Ameer, who is a professor of biomedical engineering at McCormick and professor of surgery at the Feinberg School of Medicine. "Most importantly, we may have found a way to integrate an artificial ligament with native bone."

"THE ENGINEERED LIGAMENT IS BIOCOMPATIBLE AND CAN STABILIZE THE KNEE, ALLOWING THE ANIMAL TO FUNCTION. MOST IMPORTANTLY, WE MAY HAVE FOUND A WAY TO INTEGRATE AN ARTIFICIAL LIGAMENT WITH NATIVE BONE." **GUILLERMO AMEER** PROFESSOR OF BIOMEDICAL ENGINEERING

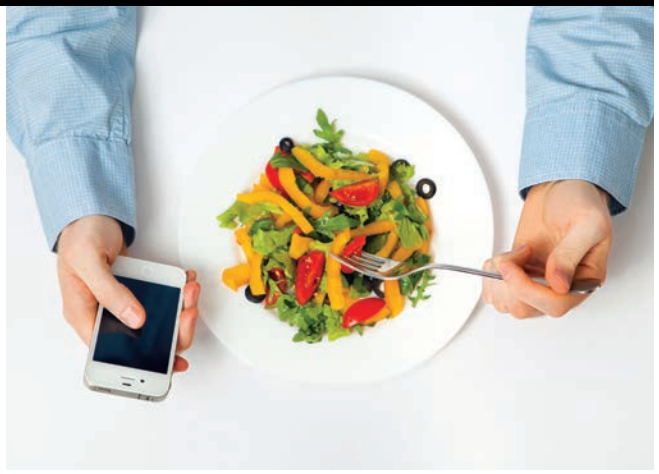


NEW PROCESS ISOLATES PROMISING FLUORESCENT MATERIAL

Professor Mark Hersam discovered a way to isolate atomically thin sheets of molybdenum disulfide (MoS_2) at a larger scale. By tuning the density of molecules used to disperse MoS_2, Hersam noted the material floated into sheets at layered positions instead of collecting at the bottom of the centrifuge tube. As MoS_2 thins to the atomically thin limit, it becomes fluorescent, making it useful for optoelectronics and light-absorbing devices.

3

The number of terminals in Mark Hersam's new memristor—an electronic circuit resistor that "remembers" how much current has flowed through it. Conventional memristors have two terminals. With an extra terminal, memristors can be used in more complex electronic circuits and systems, which could lead to brain-like computers that have more reliable memory and much faster speeds.

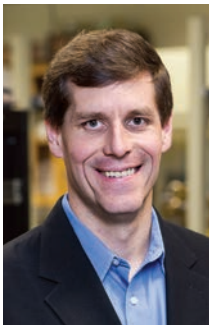


"Friending" Your Way Thin

A new Northwestern study found that online dieters with high social embeddedness—those who logged in to a weight loss website regularly, recorded their weigh-ins, and "friended" other members—lost more than eight percent of their body weight in six months. The scientists, including McCormick's Luis Amaral, found that users who did not connect with others lost about five percent of their body weight over six months. Those with a few friends lost nearly seven percent. Amaral said this online social support community approach could also work in other areas of behavioral medicine, such as depression and alcoholism.

J. Edward Colgate

Michael Peshkin



Mark Hersam

Igal Szleifer

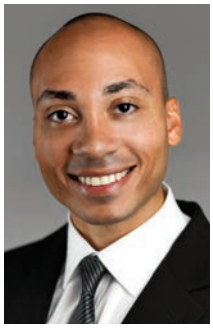
Guillermo Ameer

Kristian Hammond

Joseph Moskal

Julia Weertman

James Rondinelli



Evan Scott

Keith Tyo

Oliver Cossairt

Nikos Hardavellas

Ramille Shah

Faculty Awards

TWO PROFESSORS NAMED NAI FELLOWS

Mechanical engineering professors J. Edward Colgate and Michael Peshkin were named 2014 fellows of the National Academy of Inventors.

TWO PROFESSORS NAMED AAAS FELLOWS

Mark Hersam, the Bette and Neison Harris Chair in Teaching Excellence and professor of materials science and engineering, and Igal Szleifer, the Christina Enroth-Cugell Professor of Biomedical Engineering, have been elected fellows of the American Association for the Advancement of Science (AAAS), the world's largest general scientific society.

GUILLERMO AMEER ELECTED FELLOW OF BIOMEDICAL ENGINEERING SOCIETY

One of only nine fellows elected into the 2014 class, Guillermo Ameer, professor of biomedical engineering, was selected for his exceptional achievements in biomedical engineering.

MCCORMICK FACULTY INDUCTED INTO CHICAGO AREA ENTREPRENEURSHIP HALL OF FAME

Kristian Hammond, professor of computer science and journalism, and Joseph Moskal, research professor of biomedical engineering, were among 2014's ten inductees.

JULIA WEERTMAN RECEIVES DIVERSITY AWARD

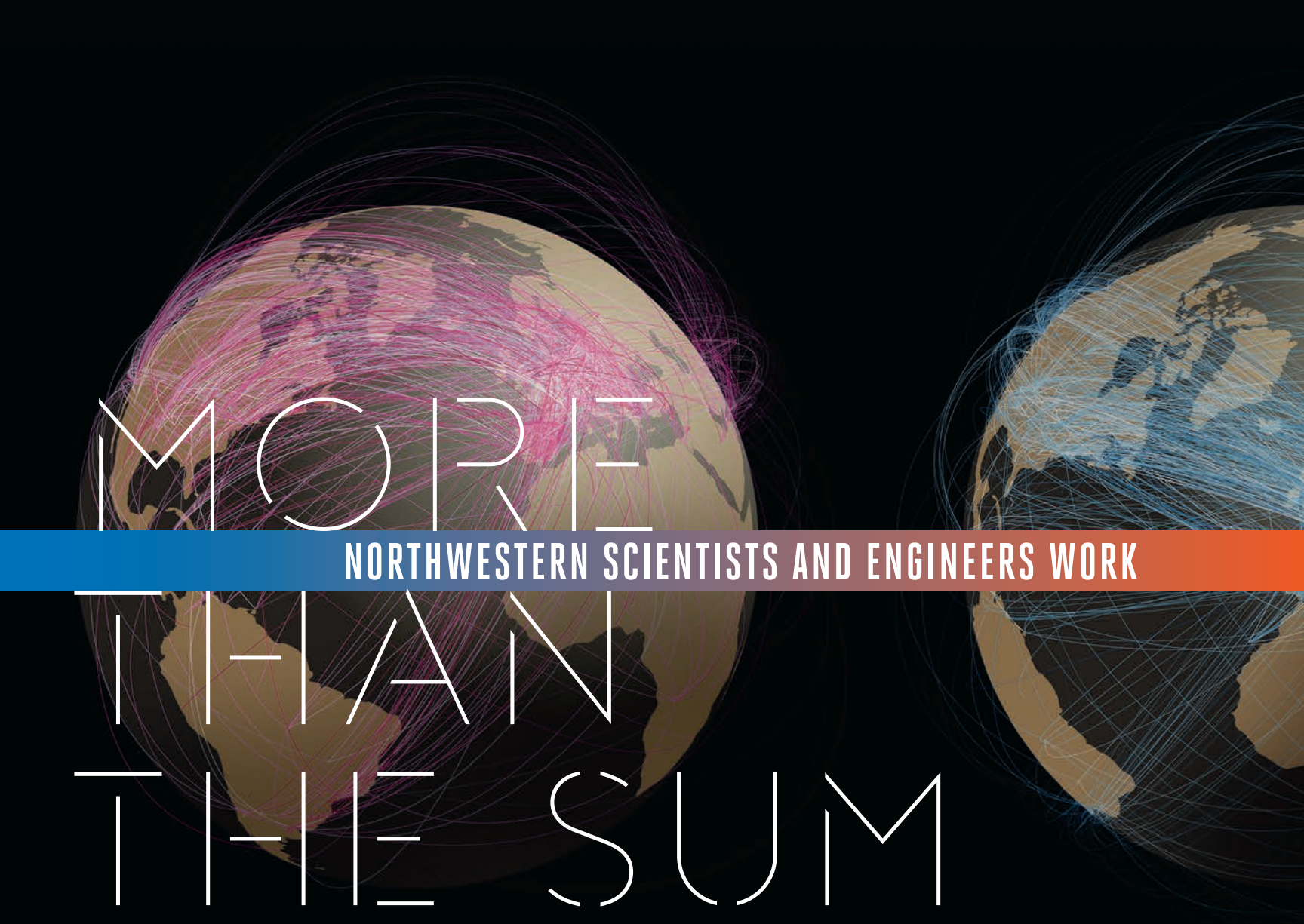
Emerita professor Julia Weertman received The Minerals, Metals & Materials Society's 2015 Ellen Swallow Richards Diversity Award.

FIVE PROFESSORS RECEIVE CAREER AWARDS

Assistant professors James Rondinelli, Evan Scott, Keith Tyo, Oliver Cossairt, and Nikos Hardavellas received prestigious Faculty Early Career Development (CAREER) Awards from the National Science Foundation.

RAMILLE SHAH NAMED TO "40 UNDER 40"

Ramille Shah, assistant professor of materials science and engineering and transplant surgery, was named to *Crain's Chicago Business*'s "40 under 40" for her work as a pioneer in the field of bio-printing.



MORE THAN THE SUM OF ITS PARTS

NORTHWESTERN SCIENTISTS AND ENGINEERS WORK

Because peer-to-peer file sharing activity is so enormous yet difficult to grasp, it is often called the "dark matter of the Internet." With unprecedented amounts of data, a Northwestern team is illuminating this little understood facet of the World Wide Web. This schematic represents a subset of BitTorrent users during one day in March 2009. Each connection indicates that at least one user is downloading a file from another, and the color indicates the type of content likely being downloaded.

TO UNDERSTAND AND PREDICT THE BEHAVIORS OF COMPLEX SYSTEMS

BY ITSELF, one neuron is nothing but a star-shaped cell in a dish. It has no sense of self or motivations or consciousness. It is awash with untapped potential. Add a few more neurons to the mix, and suddenly that potential starts clicking and firing. Add 100 billion more, and you have a busy brain—consciousness emerges, emotions are felt, and the self is defined.

Since the advent of the Internet, humans have connected with increasing ease and, like a network of neurons, demonstrated different and exciting behaviors in groups. People rarely make decisions without first asking for advice from social media "friends." They crowdsource ideas on Twitter, feedback on Facebook, and funds on Kickstarter. As seen in the image on these two pages, users—via the Internet—exchange files, movies, and music with friends and strangers all around the globe. (Read more about Luis Amaral's BitTorrent research on page 17.) Together, they weave the fabric of the future, embellishing it with shared information and pictures along the way.

"We used to think about the world from an almost entirely individual perspective," says Brian Uzzi, co-director of the Northwestern Institute on Complex Systems (NICO). "The Internet shifted people's perspectives from 'me' to 'us.'"

FOCUSING ON COMPLEXITY

Be it neural networks or human crowds, a system's parts do not necessarily provide insight into how the system will behave as a whole. The discipline of complexity science attempts to understand and predict the behaviors of complete systems. McCormick scientists and engineers have applied complexity theories widely from systems as small as the inner workings of a single cell to those as expansive as climate and social behaviors.

Through the lens of complexity, they can study how businesses make up an economy, how housing initiatives create segregated neighborhoods, how electrical connections contribute to the power grid, and how animals make up a food web. They seek to understand in detail how parts of these systems connect and work together and what happens when one piece fails.

At Northwestern, the complexity enterprise began with a few lunches among four professors: Julio M. Ottino, Daniel Diermeier, Uri Wilensky, and Luis Amaral. Starting in 2001, they met regularly to discuss their respective complexity research and discover ways their work intersected. Gradually, more and more faculty members joined these lunchtime discussions until there was enough interest to form an institute. The group established the Northwestern Institute on Complex Systems (NICO) in 2004 as a hub and facilitator for path-breaking and relevant complexity science research that transcends the boundaries of established disciplines.

"When we formed NICO, the landscape was simmering with activity," says Ottino, dean of McCormick. "We knew it was time to set up a formal center for complexity research. We wanted to be in the center of this new field and contribute to the development of new theory and tools."

Joining faculty from far-ranging disciplines, including foreign languages, social policy, industrial engineering, finance, and cell biology, Northwestern was the first university to establish such an institute to embrace the complex. "Some great universities have complexity meetings and seminars, but no other institution brings everyone together like NICO does," Wilensky says. "That's one of the reasons Northwestern stands as one of the best places in the world to study complex systems."

Indeed, the high quality of research at NICO solidifies it as a premier complex systems institute. Adding to Northwestern's eminence, Wilensky is the founder of NetLogo, the most-

"LOOKING INTO THIS WORLD OF INTERNET TRAFFIC, WE SEE A CLOSE INTERACTION BETWEEN COMPUTING SYSTEMS AND OUR EVERYDAY LIVES. PEOPLE IN A GIVEN COUNTRY DISPLAY PREFERENCES FOR CERTAIN CONTENT—CONTENT THAT MIGHT NOT BE READILY AVAILABLE BECAUSE OF AN AUTHORITARIAN GOVERNMENT OR INFERIOR COMMUNICATION INFRASTRUCTURE. THIS STUDY PROVIDES A GREAT DEAL OF INSIGHT INTO HOW THINGS ARE WORKING IN A COUNTRY." **LUIS AMARAL**

This map shows the activity of BitTorrent users during one week in March 2009. The size of each dot indicates the number of files shared by the corresponding user, and its color indicates the type of content typically shared by that user.

widely used agent-based modeling platform for the study of complex systems. With a need to better understand the increasing complexity and interdependence of the world, scientists use NetLogo to simulate actions and behavior in ways that previously seemed impossible.

"Complexity is about knowing which kinds of predictions you can make and what types of approaches are useful to handle those predictions," says Luis Amaral, co-director of NICO. "The basic idea is that the system is more than a sum of its parts."

LEVERAGING NETWORKS FOR CHANGE
LUIS AMARAL

Armed with unprecedented amounts of data, Luis Amaral has applied a complexity approach to discover insights in a number of diverse areas, including Internet usage and physicians' decisions when treating patients.

Last fall, Amaral, professor of chemical and biological engineering at McCormick and of medicine at the Feinberg School of Medicine, teamed up with Fabian E. Bustamante, professor of electrical engineering and computer science, to analyze traffic in BitTorrent, a popular file sharing system. Peer-to-peer file sharing of movies, television shows, music, and books over the Internet has surged worldwide over the past several years. Amaral and Bustamante's study of BitTorrent usage revealed the emergence of online communities organized around common interests.

Using connection patterns gathered from 10,000 BitTorrent users during a one-month period, Amaral and Bustamante discovered two surprising behavior patterns. First, most BitTorrent users are content specialists—sharing only music or movies or books but not all three. And second, users in countries with similar levels of economic development tend to download similar types of content. For example, those living in poorer countries primarily download movies.

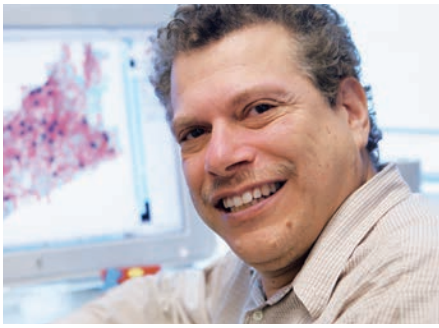
"Looking into this world of Internet traffic, we see a close interaction between computing systems and our everyday lives," Amaral says. "People in a given country display preferences for certain content—content that might not be readily available because of an authoritarian government or inferior communication infrastructure. This study provides a great deal of insight into how things are working in a country."

In another study, Amaral analyzed physician social networks, examining their professional connections and methods of sharing information. He sought to understand why one physician might recommend newly developed therapies while another might choose a more traditional route. He found that doctors are more likely to recommend a new therapy to patients when persuaded to do so by an influential colleague.

A commonly accepted belief is that physicians "catch" a new therapy in what is known as a contagion model. One doctor sees another prescribing a drug or ordering a test, becomes "infected" by the new approach, and begins to implement it.

Luis Amaral
Professor of Chemical and Biological Engineering

Professor of Medicine, Feinberg School of Medicine



Uri Wilensky
Professor of Computer Science

Professor of Learning Sciences, School of Education and Social Policy

Amaral's study, however, found the art of persuasion was more effective at boosting adoption of a new approach. The trick for physicians in influencing their colleagues was finding the sweet spot in frequency and tone of persuasive messages so they're effective and not off-putting. Along with Feinberg's Curtis Weiss, assistant professor of pulmonary medicine, Amaral found that this sweet spot took the form of a reminder message delivered every five to seven days as a strong suggestion but not an order.

"We learned how to propagate ideas among physicians without external pressure," Amaral says. "Instead of demanding people do something, you tell them it's important. Then you have those people convince other peers, and it leads to a change in culture."

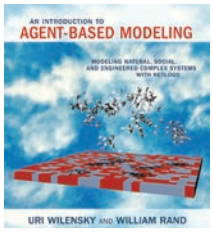
MAKING COMPLEXITY VISIBLE
URI WILENSKY

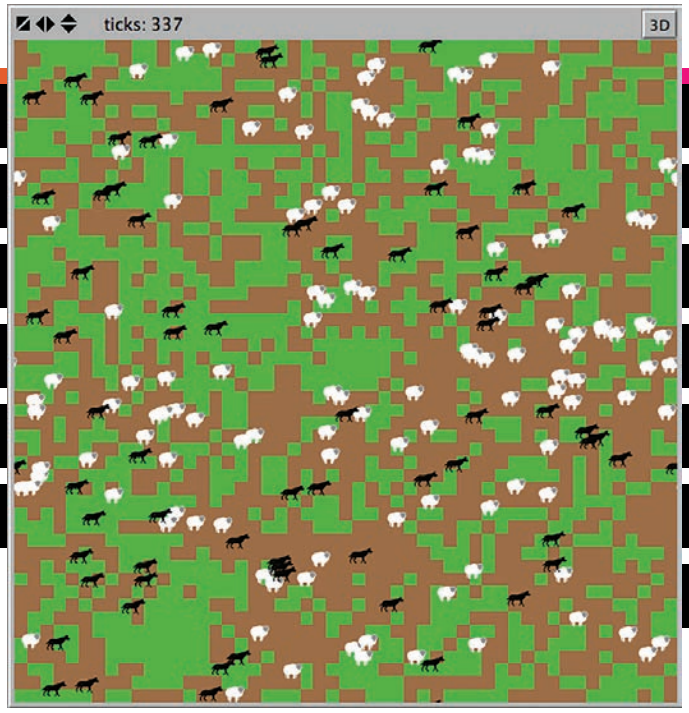
Complexity researchers everywhere are intimately familiar with Uri Wilensky's work. He is the creator of NetLogo, the most used agent-based programming language and modeling environment in the world. Wilensky began its development in 1988 as a student at MIT, where he studied how people think and learn with technology. This work lead to the creation of NetLogo, which enables users to explore and analyze the phenomena that emerge from the interactions of individuals. As NetLogo grew and evolved, Wilensky redesigned it with two seemingly conflicting goals.

"I wanted it to be easy enough for kids to use, so we could use it for education," says Wilensky, professor of computer science and learning sciences. "And I wanted it to be sophisticated enough so that researchers would use it for their high-level investigations. A lot of people didn't think we could achieve both goals, but I'm proud to say we did so in spades."

As evidence, he notes that research using NetLogo has resulted in several thousand scientific articles published in top journals. At the same time, tens of thousands of students use NetLogo in school to learn about chemistry, anthropology, economics, and more. Freely available online, NetLogo includes an extensive library of models for public use. Wilensky's new book,

"YOU START WITH A SEED AND GROW WHATEVER YOU WANT. ALL YOU NEED IS SOMETHING COMPOSED OF PARTS THAT INTERACT. THAT'S ESSENTIALLY WHAT A COMPLEX SYSTEM IS, WHICH MAKES THIS MODEL A SUITABLE METHODOLOGY FOR STUDYING COMPLEXITY." **URI WILENSKY**





Wolves, sheep, and grass are the agents in this NetLogo environment. The simulation plays out the interactions among the three agents, showing how their activities unfold over time.

An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo, was published by MIT Press in April.

Agent-based modeling is a type of computer simulation used to examine how the behavior of systems with many interacting individuals unfolds over time. NetLogo allows users to divide phenomena into different agents and give the agents properties and rules that control their behaviors and interactions. Within the simulation, agents move and follow those rules to demonstrate how the system grows and changes over time. Agents can be anything—atoms in a material, animals in an ecosystem, or people in a community.

"You start with a seed and grow whatever you want," Wilensky says. "All you need is something composed of parts that interact. That's essentially what a complex system is, which makes agent-based modeling a suitable methodology for studying complexity. The trick is to figure out how to break a system down into interesting parts."

PREDICTING CLIMATE TIPPING POINTS
MARY SILBER

When Mary Silber looks at the desert, she sees leopards and tigers. A professor of engineering sciences and applied mathematics, Silber examines satellite images of vegetation patterns that merge in semi-arid ecosystems, including regions in Niger and Sudan. The vegetation shifts as water diminishes, forming spots and stripes that, from afar, resemble the patterns in animal fur.

Analyzing vegetation patterns is just one way Silber uses mathematics to determine whether or not it's possible to anticipate when Earth's climate may be on the brink of an abrupt transition.

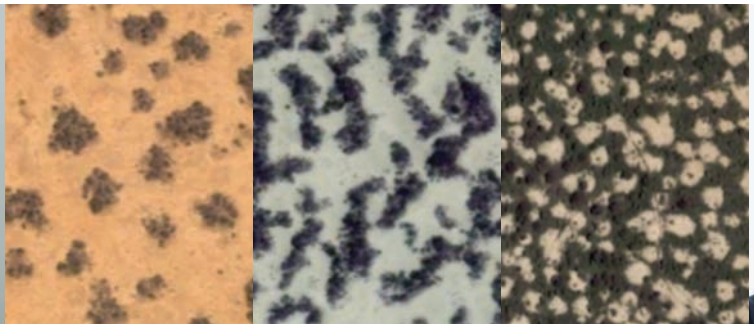
"The thing about tipping points is that they sneak up on you," she says. "And they can have very dramatic effects."

As a complex system, climate has numerous interacting components, which makes modeling difficult and tipping points potentially impossible to predict—a challenge Silber has enthusiastically taken up. She and her group are developing mathematics that will identify robust and universal qualitative phenomena associated with complex systems, including climate.

Before she could work on the problem, she needed to settle on tipping point characteristics that suggest a mathematical framing: a threshold that is irreversibly crossed, creating a significant qualitative change. This fits with her extensive knowledge of bifurcation theory, a well-established mathematical framework that explains and models how a small, smooth change in a system can cause a sudden, dramatic change overall.

The semi-arid ecosystems that Silber studies appear to be nearing a dangerous threshold. Climate change may make them increasingly arid, pushing them into deserts unable to sustain life. Viewing these ecosystems through the lens of complexity, Silber examines how climate-tipping events correspond to bifurcations. She thinks pattern formation in vegetation might tell us more about the timing of sudden transitions associated with an ecosystem's collapse under climate change. These patterns might serve as indicators that could help the world prepare for—or even prevent—going beyond the point of no return.

Mary Silber
Professor of Engineering Sciences and Applied Mathematics

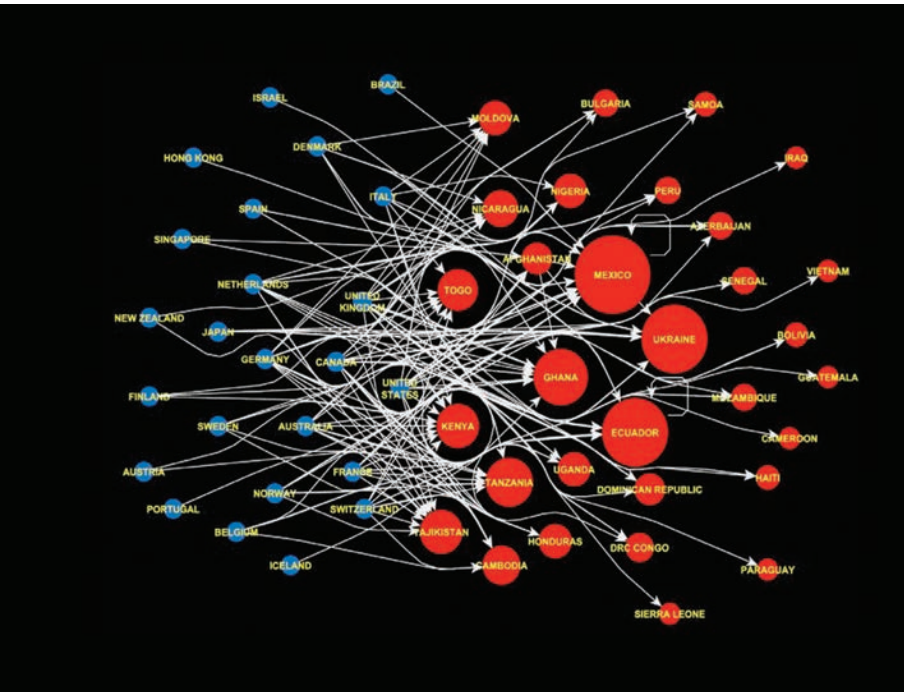


Satellite images show how the vegetation in semi-arid ecosystems arranges to form striking patterns. In a collaboration with Hermann Riecke, Mary Silber examines the patterns to determine whether they can tell us if the ecosystem is close to collapse.

Brian Uzzi
Richard L. Thomas Professor of Leadership and Organizational Change, Kellogg School of Management

Professor of Industrial Engineering and Management Sciences

"CREATIVE PEOPLE TAKE THINGS THAT ARE CONVENTIONS IN ONE FIELD AND BRING THEM INTO A NEW FIELD WHERE THEY SUDDENLY APPEAR AS INNOVATIVE. A LOT OF CREATIVE WORK EMERGES THAT WAY." **BRIAN UZZI**



Brian Uzzi's interest in determining which creative pursuits acquire funding is intertwined with his studies of creativity. He modeled the 2007 worldwide crowdfunding network to visualize the patterns that emerge when resources are exchanged. In this schematic, the blue dots indicate the lending nations, and the red dots indicate the borrowers. The size of the dots corresponds to the amount of funds loaned or borrowed.

EXPLORING COMPONENTS OF CREATIVITY
BRIAN UZZI

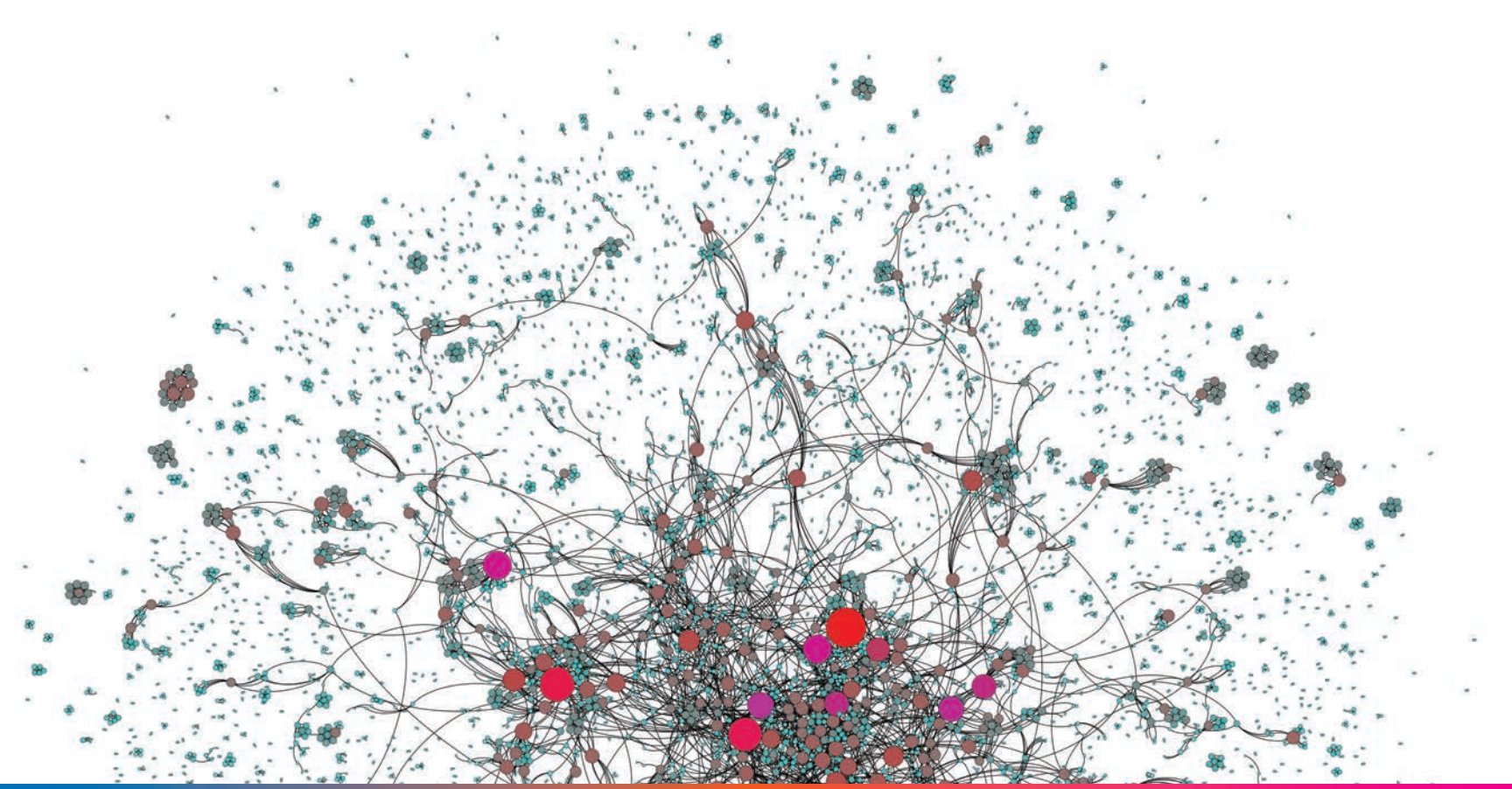
Does creativity result from a passing epiphany or a cleverly organized network?

In trying to understand what makes a piece of work creative, Brian Uzzi has taken subjects as diverse as scientific papers, Broadway musicals, and patented innovations and broken them down into their bare components. Uzzi, the Richard L. Thomas Professor of Leadership and Organizational Change in the Kellogg School of Management and, by courtesy, professor of industrial engineering and management sciences in McCormick, set out to find what mix of certain factors made a work special and new.

"Instead of spontaneously emerging from one great mind, creativity is more like an import/export business," Uzzi says. "Creative people take things that are conventions in one field and bring them into a new field where they suddenly appear as innovative. A lot of creative work emerges that way."

In one study, Uzzi examined scientific papers published since the 1950s and coded them for their component parts. He then tallied the components that appeared most frequently and studied the other components with which they most typically appeared. Uzzi found that the most celebrated papers contained a certain mix of new and old knowledge.

"Creative genius and potluck dinners have an essential commonality," Uzzi says. "The biggest hits are essentially 90 percent conventional knowledge with just 10 percent of something new and different."



"AT THE END OF THIS, WE'RE GOING TO BETTER UNDERSTAND HOW AND WHY NATURE'S DESIGNS WORK AS THEY DO. WE'LL BE ABLE TO CREATE NEW DESIGN RULES FOR CONSTRUCTIVE BIOLOGY THAT MOVE BEYOND WHAT DOES EXIST TO WHAT CAN EXIST." **MICHAEL JEWETT**

top As a part of his work to examine how networks emerge and stabilize, Contractor mapped the relationships among academic collaborators. In this network, each node is an author, and two nodes are linked when they have coauthored a paper together. The size of each node is relative to how many links it has, so an author who has written papers with many other coauthors will have a larger node.

bottom SAMDI's robotic arm deposits proteins onto a metal plate. Created in Milan Mrksich's lab, SAMDI technology can assess the biochemical activities of 100,000 compounds per day, so researchers can see how thousands of proteins interact to make a cell function.

Noshir Contractor
Jane and William White Professor
of Behavioral Sciences

Milan Mrksich
Henry Wade Rogers Professor of
Biomedical Engineering, Chemistry,
and Cell and Molecular Biology

Michael Jewett
Assistant Professor of Chemical
and Biological Engineering

ORDERING THE OPPOSITE OF CHAOS
NOSHIR CONTRACTOR

The "butterfly effect" is a popular trope in literature and cinema. Based in chaos theory, the phenomenon occurs when a minor change in a system leads to a catastrophic outcome. It happens in *It's a Wonderful Life* when George Bailey experiences a world in which he was never born, and in *Jurassic Park* when biological tampering leads to massive, unintended consequences. While Noshir Contractor is interested in chaos theory, he's even more fascinated by its lesser-known opposite: the study of self-organizing systems.

Contrary to the butterfly effect, self-organizing systems move from chaos to order. Contractor, the Jane and William White Professor of Behavioral Sciences, is interested in applying this theory to the complexity of how social structures self-order. Contractor says self-organizing systems are not stable as a result of being static; instead they are stable because they continually self-organize themselves to remain constant despite underlying chaos. He likens it to the first few weeks as a freshman at a new school.

"Initially, you randomly meet people," Contractor says. "But in a few short weeks, your social network begins to look fairly stable. You have friends you see on a regular basis, but you have to continually do things to renew the friendship."

Contractor builds rigorous computational models of self-organizing systems to examine how these networks evolve and stabilize. Based on simple social rules derived from well-established social science theories, these models are validating the use of empirical data. For example, Contractor has used such models to better understand how leaders emerge in teams, how online communities organize, and how new scientific disciplines arise. Most recently, NASA funded Contractor and his collaborator Leslie DeChurch from Georgia Tech to model team and task dynamics among individuals that the US government aeronautics agency plans to send on a mission to Mars.

"People who work in offices go home at the end of the day and don't have to see their team again until the next day," Contractor says. "Now, imagine you're stuck in a space capsule going to Mars, living a year on Mars, and traveling a year to get back to earth. There's no leaving the team. The dynamics are likely to be very different."

COAXING NATURE TO WORK HARDER
MILAN MRKSICH & MICHAEL JEWETT

From using yeast to brew beer to producing ethanol from corn, society has long employed nature to serve its needs. Synthetic biology has taken this concept a step further by turning biological systems into small, efficient factories that manufacture chemicals too expensive and tedious to produce in the chemistry lab.

This advance, however, comes with a major challenge. Popularly used biological systems, such as cells and bacteria, have their own objectives. They want to survive, eat, and proliferate and will exhibit strong resistance when forced to perform other functions.

"When we try to engineer a cell with other enzymes, that can often lead to unwanted effects on the enzymes already there," says Milan Mrksich, the Henry Wade Rogers Professor of Biomedical Engineering, Chemistry, and Cell and Molecular Biology. "It's incredibly complex to make an addition to a cell while allowing all of the existing machinery to keep operating."

Funded by Leslie and John A. "Mac" McQuown (ME '57), Mrksich and synthetic biologist Michael Jewett are working together to better understand the properties of protein networks in a cell. By developing the first large-scale assessment of such networks, they aim to coax the cells to bypass their own needs and produce molecules of interest.

"These organisms are very complex. We want to develop new tools that allow us to design within this complexity to make many different products," says Jewett, assistant professor of chemical and biological engineering.

The team's research is assisted by a technology—self-assembled monolayers desorption ionization (SAMDI)—developed in Mrksich's lab. The technology measures biochemical reactions in an extremely fast, low-cost way. SAMDI enables them to analyze thousands of cellular pathways at once while observing unintended consequences on other cellular functions.

"At the end of this, we're going to better understand how and why nature's designs work as they do," Jewett says. "We'll be able to create new design rules for constructive biology that move beyond what does exist to what can exist."

AMANDA MORRIS

Early Detection to Beat the Odds

NEW SCREENING TECHNOLOGIES DEVELOPED BY MCCORMICK'S VADIM BACKMAN HOLD PROMISE FOR DRAMATIC CHANGES IN THE DIAGNOSIS AND TREATMENT OF CANCER

"For the first time in history, we have a chance to make a real dent in cancer. This isn't a fantasy; this is very real."

VADIM BACKMAN WALTER DILL SCOTT PROFESSOR OF BIOMEDICAL ENGINEERING

In 1928, Georgios Papanikolaou, a Greek physician, made a discovery that would forever change the practice of women's health. After gathering cells from an easily accessible area, he found he could examine them under a microscope and detect early signs of cervical cancer. Soon, physicians worldwide began administering the "Pap test" during routine patient visits. Early diagnosis naturally led to early treatment, and cervical cancer death rates dropped by 90 percent.

"If we only had regular comparable screens for other types of cancer—lung, colon, and prostate, for example—we could reduce cancer deaths by ten fold," says Vadim Backman, Walter Dill Scott Professor of Biomedical Engineering at McCormick. "But when else have we seen such a discovery? Never."

Backman hopes to change that. He has developed a new suite of tools for early cancer detection and diagnostics that could potentially rival the monumental impact of Papanikolaou's test. The abnormalities that Papanikolaou noticed were clearly revealed beneath the microscope; Backman's test can detect changes that occur even earlier and on the smallest scale.

The new technologies that Backman has developed have one common denominator: they provide information about the structure and function of tissues at the nanoscale level. Catching pre-cancer at this early stage—when small dysfunctions just begin to percolate within the cells—could possibly lead to treatment before the formation of tumors and the aggressive spread of disease.

RACE AGAINST TIME

"If you look closely at the nature of cancer research throughout the world, greater than 90 percent is focused on tumors," Backman says. "The question we're asking in our research is very different."

A vast treatment gulf separates stage four cancer, which is almost untreatable, and stage one, where survival is close to 100 percent. The problem is that early-stage cancers rarely exhibit symptoms, so physicians have no indication to treat them. That's why, Backman says, early screening and diagnosis are the only ways to win the war on cancer.

Backman's potentially life-saving technology, called nanocytology, works by harnessing the power of light to examine cells from easily accessible areas of the body. A simple swab of cells from one area, such as the inside of a cheek, can uncover malignancies in a nearby organ, such as the lungs.

When researchers shine light onto the harvested cells, photons bounce off the nanostructures within them. The different angles of scattered light tell a story about the health of cells, which upon analysis can lead to an accurate diagnosis at even the very earliest stages of cancer formation. Using these bio-optic techniques, Backman can detect details indicative of "pre" pre-cancer, something that formerly could not be done with conventional microscopes.

PROTECTION THERAPIES

"Early detection is the way to go," Backman says. "But there are people who have cancer right now, and they need therapeutics."

Functional changes that are not well understood happen in early stages of cancer. Backman's work has given the community a fuller understanding of what happens during cancer formation. It has also illuminated pathways for new therapeutic targets.

Backman is particularly interested in chromatin, a macromolecule that resides within a cell's nucleus and controls gene expression. "If proteins and DNA are the tools that make our bodies work, then chromatin is the hand that chooses the tools," he says. "For cancer to arise, genes must become altered, mutated, or expressed. The only way for this to happen is for the chromatin to allow it. That's what drives the cancer."

Instead of battling the outcome of gene expression, Backman wants to thwart dysfunctional gene expression before it happens. He has developed a nanocytology technique that, for the first time, allows researchers to look at chromatin in living cells without toxic stains or labels and is working on ways to control the chromatin in order to prevent it from causing cells to become cancerous.

MAKING A REAL DENT

Such new therapies might lie down a distant road, but Backman's early detection technique could soon be available for physicians to use with their patients. Several large clinical trials are already in progress, and three tests—for lung, colon, and prostate cancer, which are also the most common types—should enter the market within one to three years.

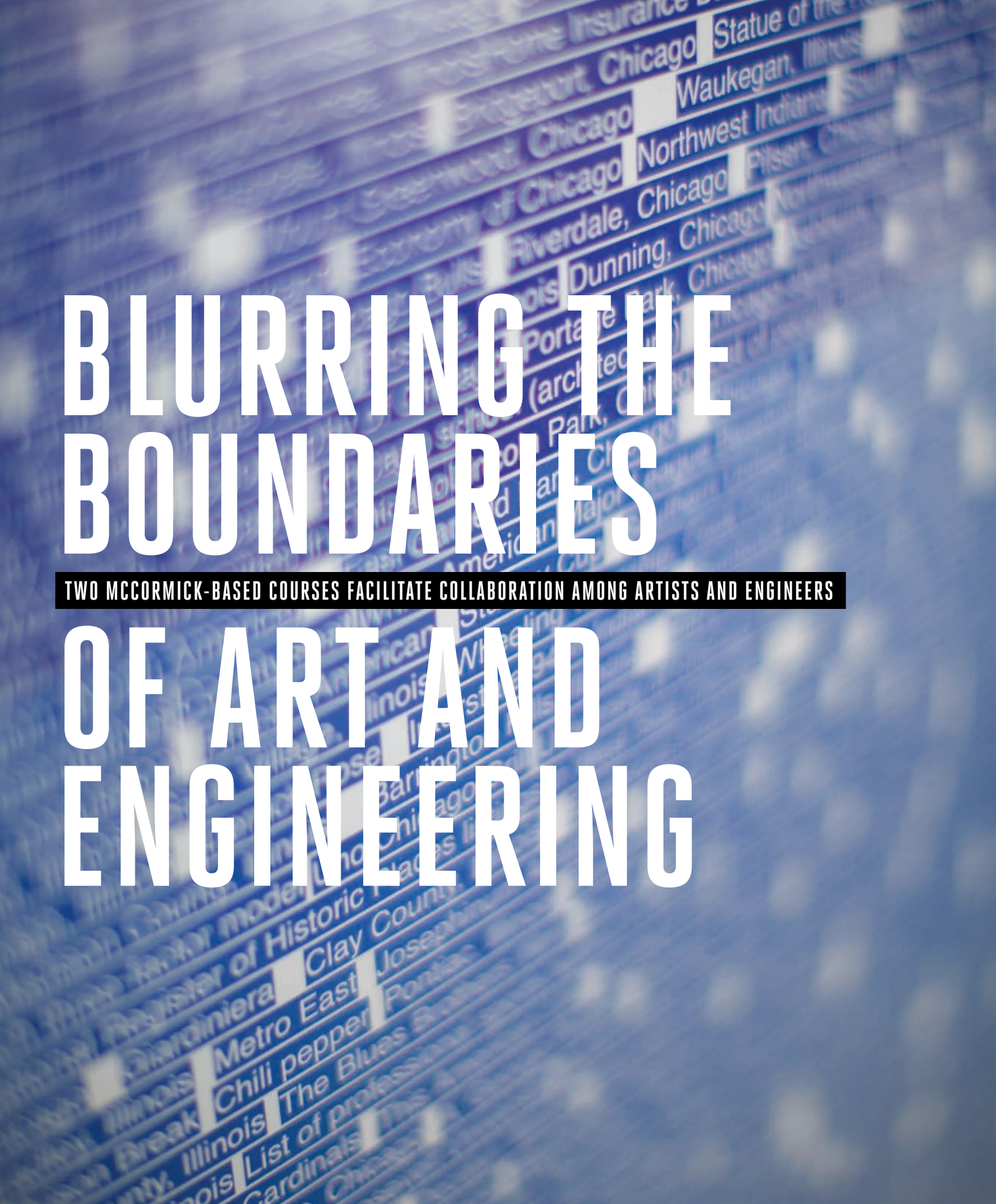
Replacing colonoscopies and prostate-specific antigen tests with Backman's screens would make testing less invasive, less expensive, less risky, and more accurate. Backman is also developing screens for ovarian and pancreatic cancers, which will be available further down the road.

Much like the Pap test, these new screens could become a part of regular primary care so physicians would always be one step ahead of cancer, ready to prevent it from getting out of control. For example, dentists could automatically screen smokers for lung cancer during a routine checkup.

"For the first time in history, we have a chance to make a real dent in cancer," Backman says. "This isn't a fantasy; this is very real."

AMANDA MORRIS

Photograph by Chris Strong



BLURRING THE BOUNDARIES OF ART AND ENGINEERING

TWO MCCORMICK-BASED COURSES FACILITATE COLLABORATION AMONG ARTISTS AND ENGINEERS

IN THE LATE HOURS OF FRIDAY, DECEMBER 28, 2007, a Wikipedia editor named Unnatural Gas sliced through the site's page on global warming, dragging his electronic red pen through the page's "weasel words." Mere seconds later, another editor named Brusegadi reinstated the deleted words. "Not weasel words," he typed. "They are from sources."

Seven years later, Northwestern's Steph Shapiro, a senior studying design and sociology, and her team sorted through that same page's extensive history of past edits, noting the back and forth debates over even the smallest details.

"Wikipedia editors aren't researchers," she says. "So they have their own influences that cause them to change the information. There are many behind-the-scenes debates as editors work toward consensus."

The successive edits served as the inspiration for and substance of an art installation called [*View history*] that visually reveals the evolution of Wikipedia's hotly contested global warming entry. The installation is one of four final course projects that emerged from Data as Art, a fall-term offering co-taught by faculty from Northwestern University and the School of the Art Institute of Chicago (SAIC).

Another similarly interdisciplinary course, Artists and Engineers Collaborate, is offered in partnership with the Weinberg College of Arts and Sciences, and provides new opportunities for art and engineering students to enhance the way they see, perceive, and interact with the world.

Both courses are part of a series of initiatives designed to bridge the boundaries of art and engineering, to break down the expectations of conventional thinking, and to help students look at problems in new ways. The Barry and Mary Ann MacLean Fund for Arts & Engineering supports both courses.

BIG, BEAUTIFUL DATA

Now in its second year, Data as Art challenges students from both Northwestern and SAIC to work together to translate complicated data sets into visual art or images that an average viewer can understand. Each interdisciplinary team included students from the McCormick School of Engineering and Applied Science, which organized the collaboration through the Segal Design Institute. The final projects went on public display in December at the SAIC's LeRoy Neiman Center in downtown Chicago and later moved to the Ford Motor Company Engineering Design Center on Northwestern's Evanston campus.

The [*View history*] team spent 28 hours printing the past Wikipedia entries about global warming onto sheets of Plexiglas.® The sheets were then arranged with the newest entry in front and the oldest in the rear. A viewer standing in front of the stack can literally see through the progression of edits, back to pages that have long since been deleted from public view. Books placed beside the Plexiglas structure share comments and conversations from the site's editors.

"It's like you're looking back in time," said Julia Torres, a second year student in the Master of Fine Arts program at the SAIC and part of the [*View history*] team. "Wikipedia strives to be neutral, but what is the relationship between neutrality and truth? It's interesting to see how that works out in a collaborative document."

SOLVING MEANINGFUL PROBLEMS

After Data as Art wrapped up its second successful year, the second boundary-blurring course, Artists and Engineers Collaborate, was offered for the first time. The new offering limited interdisciplinary collaborations to students at Northwestern. Co-taught by McCormick's Malcolm MacIver and Weinberg's Jeanne Dunning, students from art and engineering converged on projects and learned from one another's cognitive styles.

"ENGINEERS AT MCCORMICK ARE TRAINED FOR PROBLEM SOLVING. THEY ARE GIVEN A PROBLEM BY A CLIENT, AND THEY SOLVE IT. ARTISTS ARE TAUGHT TO FIND A PROBLEM, SO THE ARTIST'S PROBLEMS ARE OFTEN INTERIOR IN SOURCE, WHILE THE ENGINEER'S ARE OFTEN EXTERIOR."

MALCOLM MACIVER

"Engineers at McCormick are trained for problem solving," MacIver says. "They are given a problem by a client, and they solve it. Artists are taught to find a problem, so the artist's problems are often interior in source, while the engineer's are often exterior."

Graduate student Laura McGinn enrolled in Artists and Engineers Collaborate because she liked the idea of working with people from different academic backgrounds. Ironically, her project took a more personal turn when MacIver and Dunning challenged her and her classmates to complete social practice art projects, a type of art that combines practicality and usefulness with aesthetics for the purpose of social engagement.

McGinn chose this as an opportunity to solve a meaningful problem that hit very close to home. Having grown up with a brother who stands at the high-functioning end of the autism spectrum, she knows how frustrating communication can be.

"You want to communicate," says McGinn, who studies art theory and practice. "But it's tricky to bridge that gap."

Photograph by Chris Strong

Inspired by her brother, McGinn and her team initially planned to develop a board game to help autistic individuals improve their communication skills. The team quickly shifted focus after discovering that many such games already existed in the marketplace.

They did find, however, that nothing existed to help the non-autistic learn how to facilitate interactions with their autistic colleagues in the workplace. Through interviews and research, the team discovered that a lack of education among employers and co-workers created a difficult environment for autistic individuals to succeed, leading to an unusually high rate of unemployment among them.

The team's ability to change its plan based on their research impressed Dunning and MacIver. "You can't solve a problem based on preconceived notions," Dunning says. "When they really dug into their project, their opinions changed based on what the research revealed."

The result of that work was Spectrum, a collaborative game in which participants place cards on the playing board in a pre-set pattern. Working together with restricted communication, non-autistic players gain a basic understanding of some of the communication challenges those with autism face in traditional work environments.

Have Dreams, a Chicago-area autism resource, has expressed interest in implementing Spectrum in its program. The development team is also building a website where potential users can download the game and print playing cards.

WHOLE-BRAIN LEARNING

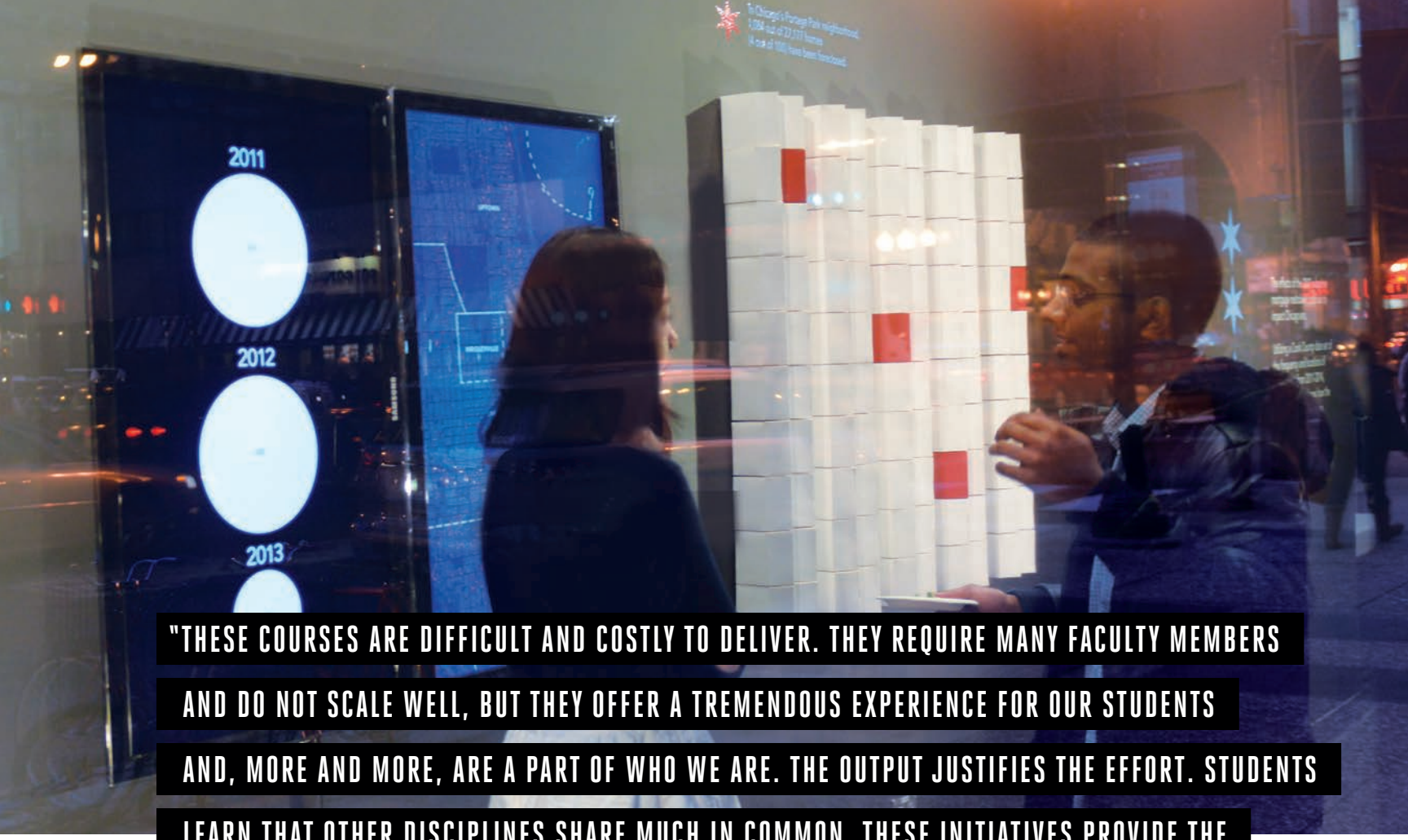
Although the students in both courses—Data as Art and Artists and Engineers Collaborate—came from different disciplines and used different vocabularies to express themselves, they were not encumbered by stereotypical divisions when working together. In fact, as they came to appreciate and learn from one another's divergent talents and cognitive styles, they changed the way they thought about their own work and goals.

"It was interesting to see how people just naturally wanted to try different roles," says McGinn. "The art students tried to be more pragmatic; the engineers wanted to be more poetic. The experience offered a place to experiment outside of our usual mode of thinking."

"I usually think about presenting my work for the scientific community," says Vijay Murganoor, a graduate student in computer science who participated in Data as Art. "I've now started thinking in more aesthetic terms and not just in numbers. This class has shown me a way to present my work that can reach many more people."

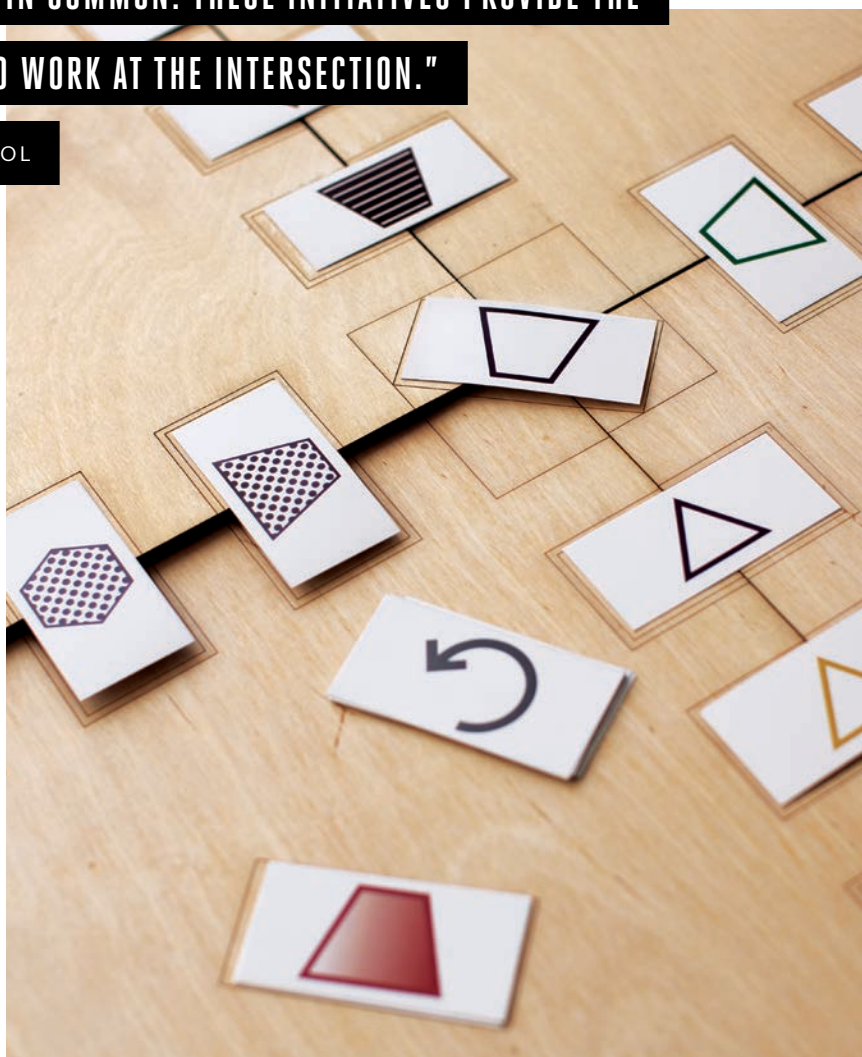
"These courses are difficult and costly to deliver," says McCormick Dean Julio M. Ottino. "They require many faculty members and do not scale well, but they offer a tremendous experience for our students and, more and more, are a part of who we are. The output justifies the effort. Students learn that other disciplines share much in common. These initiatives provide the opportunity for our students to learn to work at the intersection."

AMANDA MORRIS

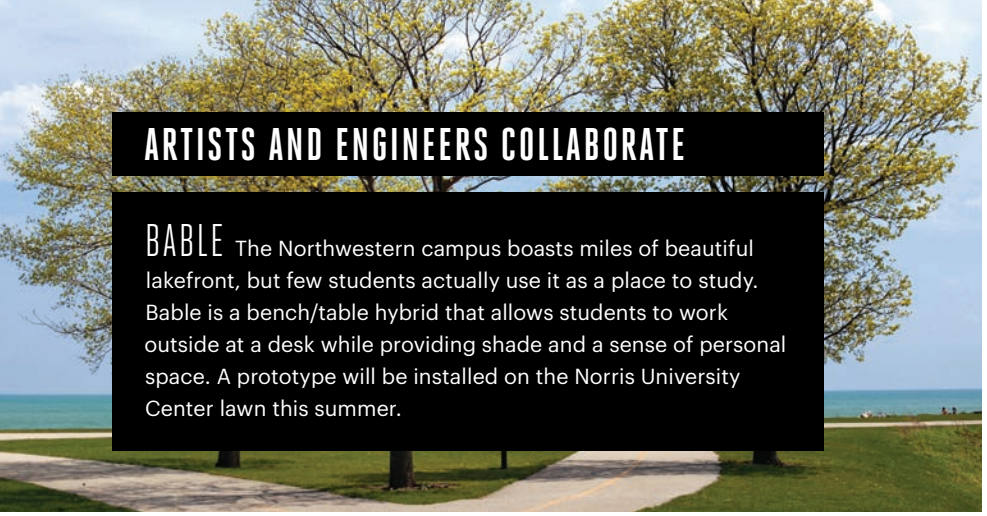


"THESE COURSES ARE DIFFICULT AND COSTLY TO DELIVER. THEY REQUIRE MANY FACULTY MEMBERS AND DO NOT SCALE WELL, BUT THEY OFFER A TREMENDOUS EXPERIENCE FOR OUR STUDENTS AND, MORE AND MORE, ARE A PART OF WHO WE ARE. THE OUTPUT JUSTIFIES THE EFFORT. STUDENTS LEARN THAT OTHER DISCIPLINES SHARE MUCH IN COMMON. THESE INITIATIVES PROVIDE THE OPPORTUNITY FOR OUR STUDENTS TO LEARN TO WORK AT THE INTERSECTION."

JULIO M. OTTINO DEAN OF THE MCCORMICK SCHOOL

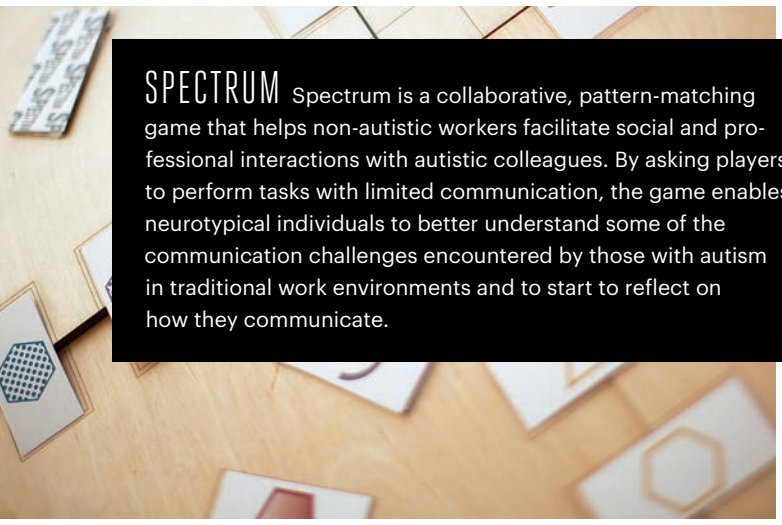


ARTISTS AND ENGINEERS COLLABORATE

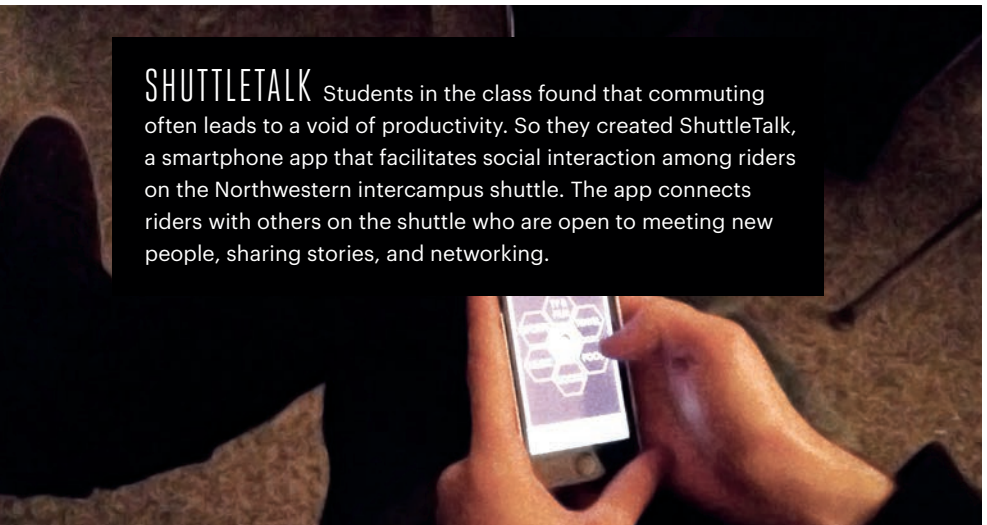


BABLE The Northwestern campus boasts miles of beautiful lakefront, but few students actually use it as a place to study. Bable is a bench/table hybrid that allows students to work outside at a desk while providing shade and a sense of personal space. A prototype will be installed on the Norris University Center lawn this summer.

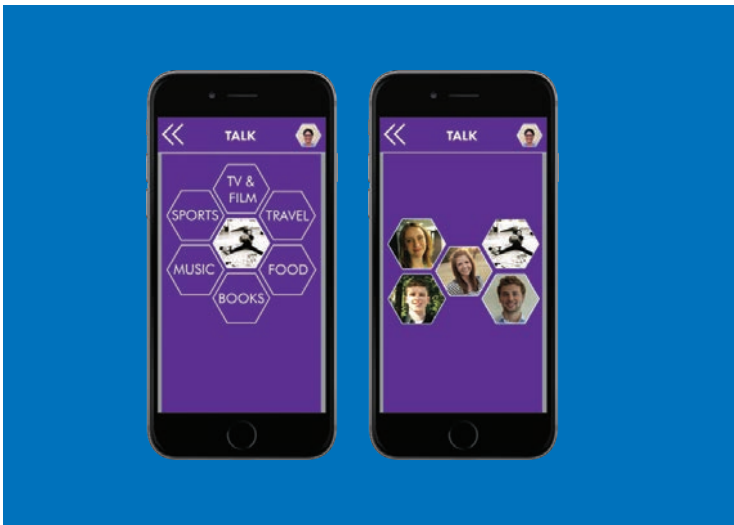
SPEAK UP! Street harassment is a pervasive problem in many cities worldwide. One team recognized the influence of bystanders in these situations and aimed to empower them to intervene. *Speak Up!*, a public installation in downtown Chicago, promoted awareness of street harassment and offered phrases that witnesses could verbalize to intervene.



SPECTRUM Spectrum is a collaborative, pattern-matching game that helps non-autistic workers facilitate social and professional interactions with autistic colleagues. By asking players to perform tasks with limited communication, the game enables neurotypical individuals to better understand some of the communication challenges encountered by those with autism in traditional work environments and to start to reflect on how they communicate.



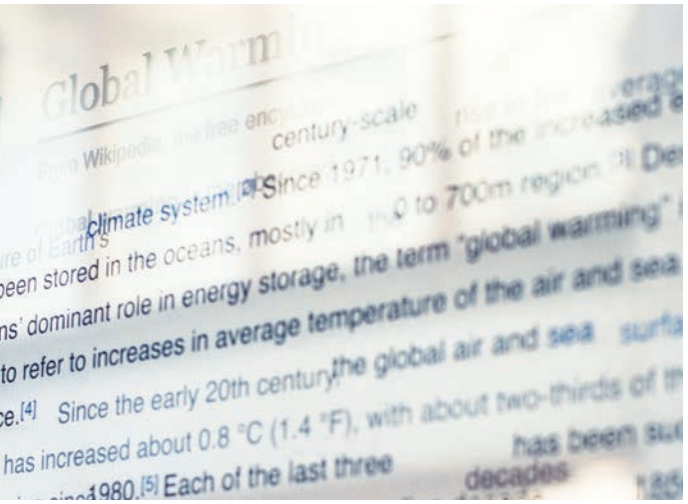
SHUTTLETALK Students in the class found that commuting often leads to a void of productivity. So they created ShuttleTalk, a smartphone app that facilitates social interaction among riders on the Northwestern intercampus shuttle. The app connects riders with others on the shuttle who are open to meeting new people, sharing stories, and networking.



DATA AS ART

WIKITROPOLIS

The *Wikitropolis* group investigated the link-system architecture of Wikipedia by examining the entries about five cities: Chicago, London, New York, Paris, and Tokyo. Each city was represented by its own three-dimensional, skyline-like pillar, which was papered with links from its Wikipedia page. The links darkest in color were unique to one particular city while lighter links represented more common features.



[VIEW HISTORY]

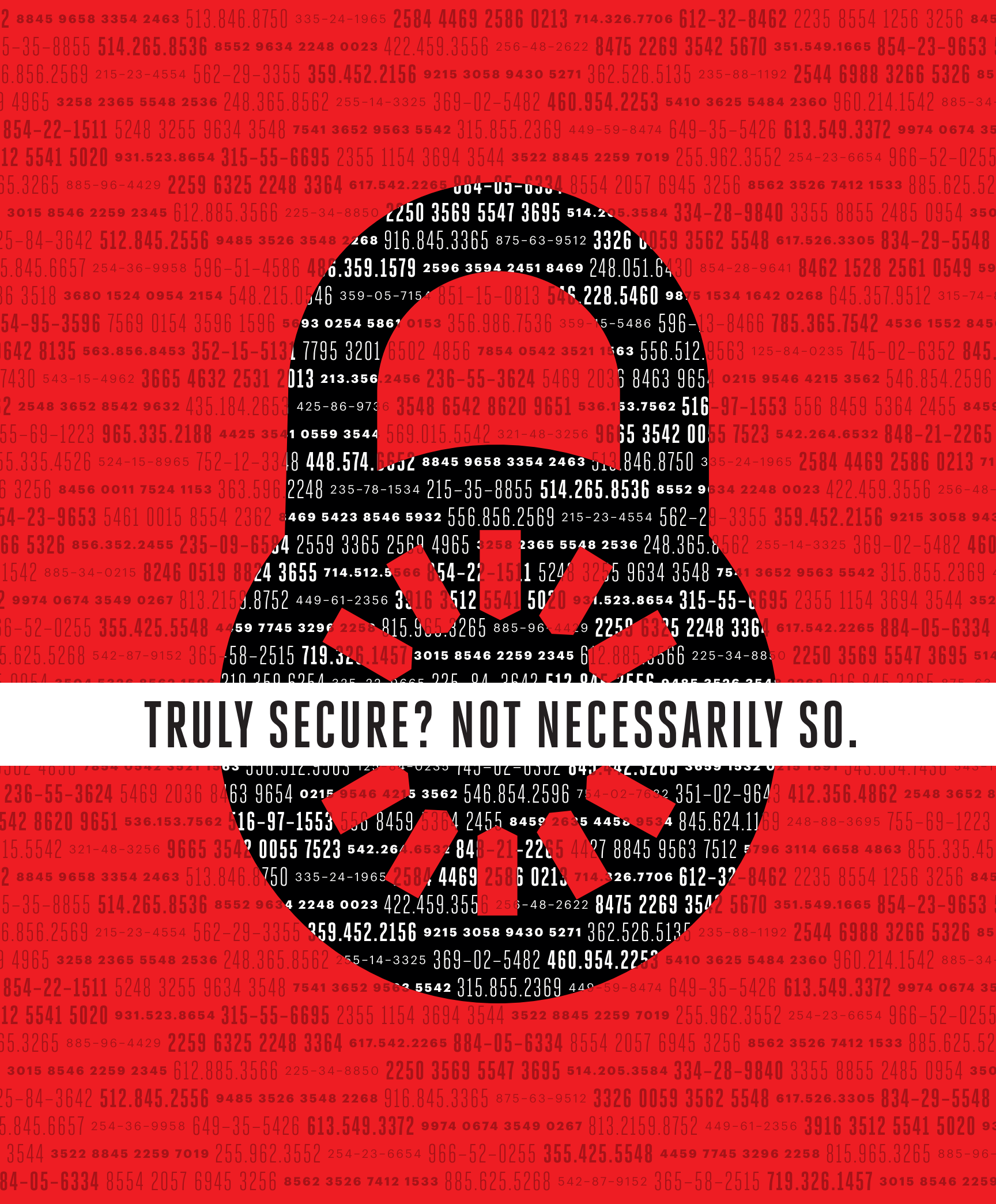
[*View history*] visually demonstrates the evolution of content on Wikipedia's "Global Warming" page to illustrate the chronological development of the article, the information that has been deleted, and the debates among the individuals who have edited the article. The installation invites people to examine the significance and power of editing a collaborative document and to question the information sources that influence public opinions on scientific topics, especially in light of climate change denial.

RENDERED GHOSTS

Working with Chicago housing data, the *Rendered Ghosts* team created an installation showing the recent history and ongoing social and political effects of the foreclosure crisis. An interactive monitor displayed the frequency and location of foreclosures in Cook County, including an in-depth look at the Portage Park neighborhood, which has one of the highest foreclosure rates in the city. The project also included a town of 3D printed houses painted in different colors to represent foreclosure statistics.

UN*SPOKEN

An interactive installation called *Un*spoken* explored the similarities and differences between laughter and crying. The team translated a database of sounds into music, which was then printed in dot compositions on strips of paper to be played through a hand-crank music box. While it was hard to distinguish the differences between laughing and crying—two very different yet parallel emotional responses—the team found that baby sounds were more complicated than adult sounds.


TRULY SECURE? NOT NECESSARILY SO.

WELL BEFORE RECENT, HIGH PROFILE INTERNET SECURITY BREACHES CAME TO LIGHT, MCCORMICK RESEARCHERS WERE DEVELOPING NEW TOOLS TO PINPOINT VULNERABILITIES AND STOMP OUT THREATS.

You keep unique passwords. Run the latest anti-virus software. Order only from the most trusted online vendors. Your online information is secure, right? Maybe not.

In April 2014, millions of Internet users were forced to face the harsh reality that their most valuable information—Social Security numbers, credit card information, email passwords, and more—potentially had been compromised, all because of a simple, overlooked software programming bug called Heartbleed.

The flaw had exposed a loophole in the OpenSSL security protocol, a type of encryption software that provides security among devices connecting over a network. For hackers, the bug created an easy entry point for acquiring passwords that ostensibly protect such sensitive information as financial records, healthcare databases, and email communication.

In the weeks and months that followed the revelation, software developers seeking to protect the estimated two-thirds of web servers susceptible to Heartbleed released software patches and implored users to change their passwords. Unfortunately, the potential for damage had already been unleashed. As *The Washington Post*'s Lindsey Bever put it, "It's as if someone went on vacation not knowing the lock on the front door was broken. Could someone walk in? Yes. Will they? Did they? Who knows?"

COLLABORATING TO THWART VULNERABILITIES

The Internet, often analogized to the Wild West, thrives in a largely unregulated infrastructure that has spawned countless valuable technological innovations. Too often, however, security considerations have come as an afterthought—something McCormick researchers hope to change.

More than a year before the public became aware of the Heartbleed bug, Yan Chen, professor of electrical engineering and computer science, and his research team had set out to develop an automated approach that could locate similar security vulnerabilities in other SSL encryption protocols like OpenSSL.

"Almost all Internet authentication systems are based on SSL, which means these vulnerabilities are inherent to the Internet as a whole," Chen says.

Collaborating with researchers at the University of Illinois at Chicago, Columbia University, and Zhejiang University in China, Chen's team created and implemented SSLint, a programming tool that can accurately and efficiently scan a security software's source code and detect vulnerabilities.

To test SSLint, the researchers spent two years analyzing millions of lines of code within 485 different SSL and TLS security programs. They uncovered 27 previously unknown vulnerabilities.

"Previous studies had failed to reveal the scale of SSL vulnerabilities. The sheer number we found indicates either widespread inexperience or unwitting carelessness of some developers," says Vaibhav Rastogi, a PhD candidate in Chen's group and co-author of the study. "SSL and its successor TLS form the security backbone of the Internet, and vulnerabilities betray the trust people place in it. Users are left exposed to spying and modification of their communications."

Similar to Heartbleed, the vulnerabilities Chen's team found came from security packages already in use, including some that have been downloaded hundreds of thousands of times. The researchers approached the developers of the programs in question and pinpointed the exact location of the vulnerabilities so patches could be built to treat them.

"A lot of the developers took our advice," Rastogi says, noting that the team received at least 14 confirmations of patches in development. "Security techniques still need a fundamental redesign, but there has been improvement."

TOP-OF-MIND, NOT SECOND THOUGHT

For Aleksandar Kuzmanovic, associate professor of electrical engineering and computer science at McCormick, the Heartbleed bug symbolizes a broader trend. He observes that developers often push new software or mobile apps to market as quickly as possible, content to react to security breakdowns as they occur instead of addressing cyber security threats proactively.

"A Facebook application may make sense from a system design perspective, but not from a security perspective," says Kuzmanovic, whose recent research quantified the privacy leaks present when using social networks on mobile devices. "As soon as the app works, there's a rush to put it online. If something goes wrong, they'll deal with it then."

One lesson that Heartbleed has taught: no matter how tough your security protocol, vulnerabilities exist, and information placed online has the potential to be compromised. That uneasiness won't go away anytime soon.

"Security is improving," says Chen. "But there's still a long way to go before we can truly call the Internet secure."

ALEX GERAGE

DEVELOPING MEDICAL DEVICES FOR THE DEVELOPING WORLD

MCCORMICK STUDENTS STUDY AND WORK TO IMPROVE HEALTHCARE IN CAPE TOWN

A “rainbow nation” of races and cultures. Eleven official languages. A potent mix of developed and developing worlds. South Africa is a country of contradictions. Nowhere is that more evident than in Cape Town, where cosmopolitan shopping malls and luxury beach homes stand in startling contrast to the makeshift shantytowns just a stone’s throw away.

For the 16 Northwestern students who traveled to Cape Town this spring as part of McCormick’s Global Health Technologies study abroad program, those contradictions are exactly what drew them there. For 10 weeks, in conjunction with their studies at the University of Cape Town, they visited community healthcare clinics, interviewed healthcare workers, and created devices and processes to help improve healthcare delivery.

Of course, they knew they weren’t going to solve the region’s problems in 10 short weeks. They did, however, gain a valuable first-person perspective of what it means to design for a new culture, where, for example, patients don’t have the same notion of making appointments, or where electrical power frequently goes out.

DESIGNING FOR A NEW CULTURE

“Our students in this program get a true sense of design,” says Matthew Glucksberg, the professor of biomedical engineering who heads the program through McCormick’s Center for Innovation in Global Health Technologies. “They can’t just fall back on what they know. They must take their engineering skills and seek solutions that could actually work in resource-limited settings.”

By living and working together in a house near campus (where the posted house rules range from “wash pans after using” to “assume best intentions”), students could spend much of their time iterating designs, getting feedback from their professors and from users, and then working together to start the process all over again.

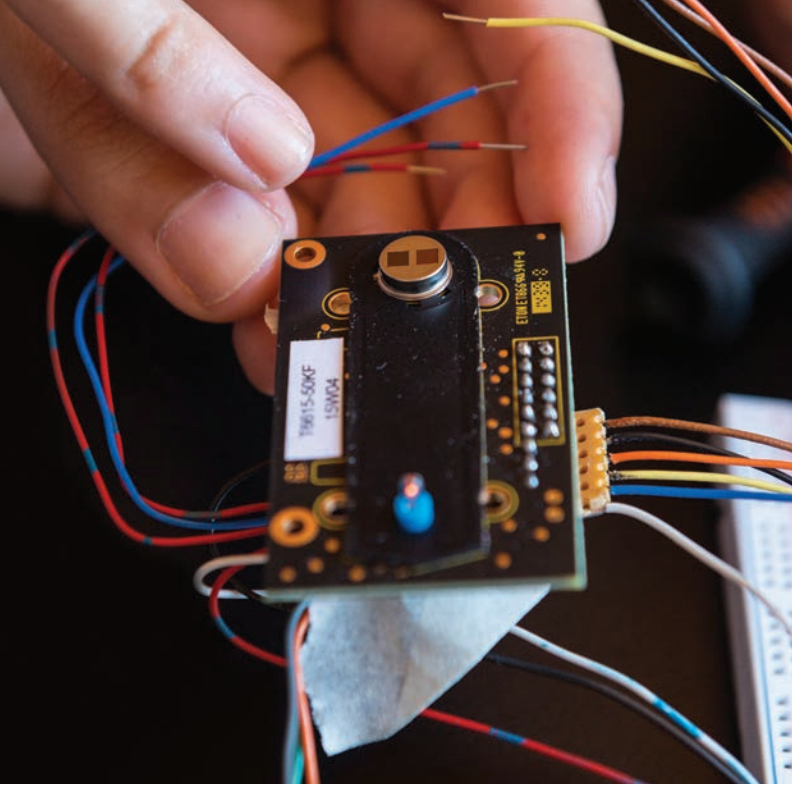
At the end of the quarter, the group had four prototypes: a simple carbon dioxide detector to help paramedics intubate patients, a tablet app to help clinic nurses diagnose diseases and prescribe treatments, a new kind of mask for protecting against tuberculosis, and an app for a clinic kiosk that would help patients book appointments.

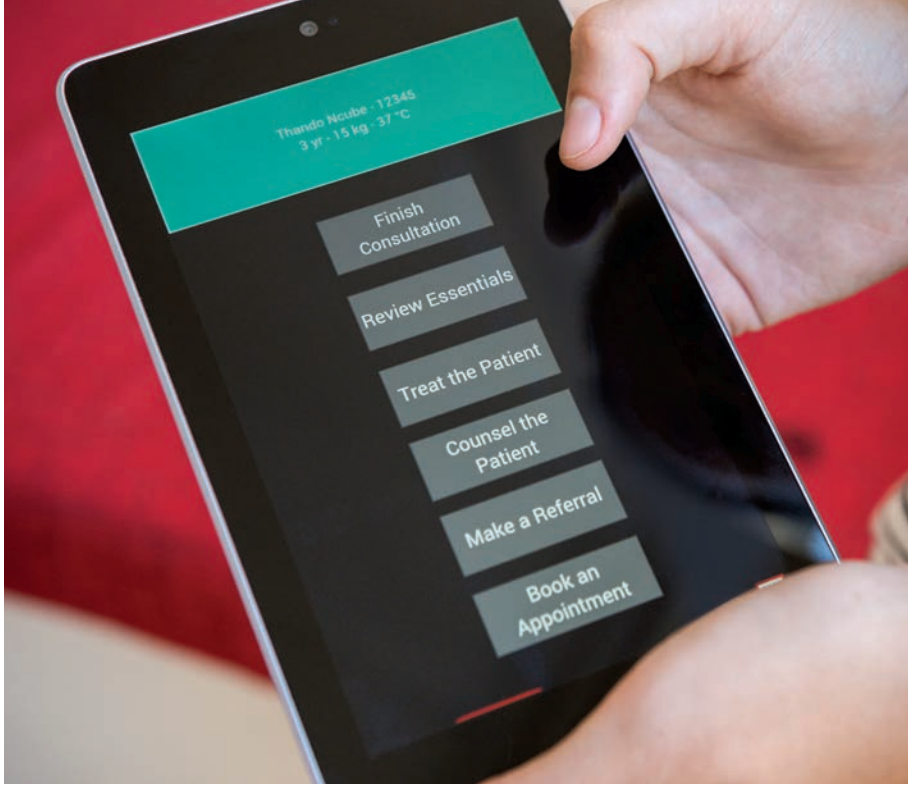
Such projects require years of work before they are ready for clinic implementation, but the lessons the students learned can be applied as they graduate and move on to their careers.

“It’s not just us coming in and saying, ‘We’re going to help save you,’” says student Petrina LaFaire (biomedical engineering ’15). “It’s very much a learning process for us, and that has been great. I’ve learned that failure is okay. Iterating an idea is not only acceptable, it’s necessary.”

EMILY AYSHFORD

Photos by Patrick L. Pyszka





ETCO2 INDICATOR

Problem: Breathing difficulties. When paramedics intubate patients with breathing tubes, they often have difficulty determining whether they've inserted the tube down the trachea, which leads to the lungs, or down the esophagus, which leads to the stomach. Esophageal intubation can lead to death.

Solution: A carbon dioxide sensor. The team originally focused on creating a capnograph, which creates a graph of carbon dioxide coming from the lungs over time, but concluded that would be too expensive and more complicated than necessary. "We realized the best way to cut costs is to cut out some functionality," says team member Hannah Baiyor (biomedical engineering '15). "Instead of a graph, we created a sensor that can determine whether or not air is coming from the lungs. It's an LED light that says 'yes' or 'no.' We learned that high tech doesn't necessarily mean better. Sometimes, a simpler design is actually the best."

Challenges: Material procurement. The project required optical equipment, which had to be ordered from the United States. "We had issues with customs," says team member Eric Yang (biomedical engineering '15). "We had to email for several weeks to figure out how we would get these components in our hands."

Lessons Learned: Designing for the developing world. "You can't just build something and expect it be universally acceptable," Baiyor says. Students found, for example, that many medical devices that are considered disposable in the United States are used several times in the clinics. "You also can't just donate old medical devices to the developing world," Yang says. "It's not as simple as saying, 'We don't want this anymore, maybe they can use it.' If it doesn't work for us, it's not going to work for them."

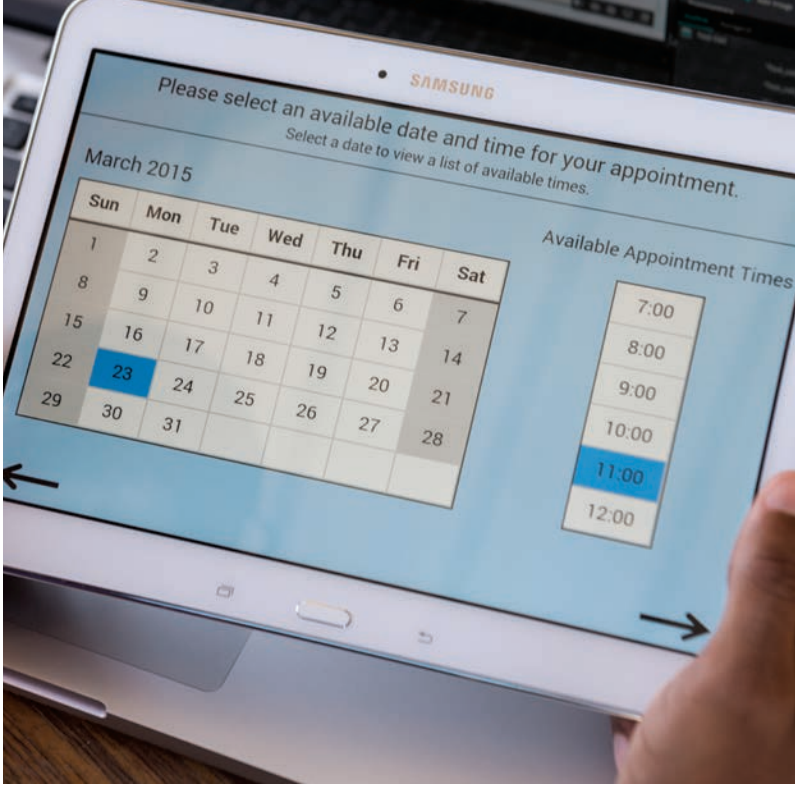
IMCI+ TABLET APPLICATION

Problem: Diagnosing the right disease. When confronted with common ailments like fevers, diarrhea, and ear problems, clinic nurses often turn to *Integrated Management of Childhood Illness* (IMCI), a handbook created by the World Health Organization and UNICEF that helps them assess and treat childhood illnesses in resource-poor environments. Five years ago, McCormick students in the study abroad program created an Android tablet app to make the guide digital. Feedback showed that nurses actually took longer to find a diagnosis using the app than the handbook. "We wanted to streamline the process and make it more accurate and thorough," says team member Nick Brandis (civil engineering '15). "We wanted nurses to see it as useful enough to warrant the time it would take."

Solution: A new version of the app. The team expanded the app by adding modules that allow nurses to see a patient's history, prescribe treatments, access counseling material, and book another appointment. "It adds time, but these steps are all part of the consultation anyway, so it saves paperwork," says team member Tessa Swanson (industrial engineering '16).

Challenges: Limited timeframe. The team submitted a request to conduct user testing, but approval wasn't communicated back to them for several weeks. That meant they had to scramble to conduct user testing in their final weeks.

Lessons Learned: Project management. "With such a short timeframe, you really need to break down your priorities and establish your methods for reaching your goals," says team member Kera Scheffel (biomedical engineering '15). "You need to recognize early on what resources are available."



TUBERCULOSIS PERSONAL PROTECTOR

Problem: Uncomfortable protective masks. In South Africa, where tuberculosis affects about 500,000 residents a year, protecting healthcare workers from contracting the disease is extremely important. But current paper masks that cover the nose and mouth are unpopular among clinic staff. "The masks are uncomfortable, and they make it hard to breathe," says team member Danielle Marks (biomedical engineering '15). "They cause rashes and irritate the skin, so many workers don't wear them at all."

Solution: A redesigned mask. The team developed a new mask that incorporates a plastic face shield and an airflow system that blows purified air toward the healthcare worker's face. The system uses an ultraviolet germicidal irradiation lamp worn in a backpack that draws in potentially infected air, treats it, and directs it through a tube toward the worker's mouth. A plastic face shield attached to the pack and positioned a few inches away from the face protects the worker from patients' coughs and sneezes without irritating the skin.

Challenges: Access to machinery and materials. Although the University of Cape Town has a machine shop, students have only limited access to the machinery. The students also found that securing parts for the protector was more challenging than making a quick trip to a nearby big box store. "The materials we needed had to be sourced from small local shops," says team member Mike Aleman (mechanical engineering '15).

Lessons Learned: Coping with conflicting opinions. "When we interviewed nurses, some said they wanted a mask one way, but then others said they didn't want it like that at all," says team member Regan Via (biomedical engineering '15). "It highlights the importance of learning exactly what your clients really need, and figuring out what that means for a client who has a perspective very different from yours."

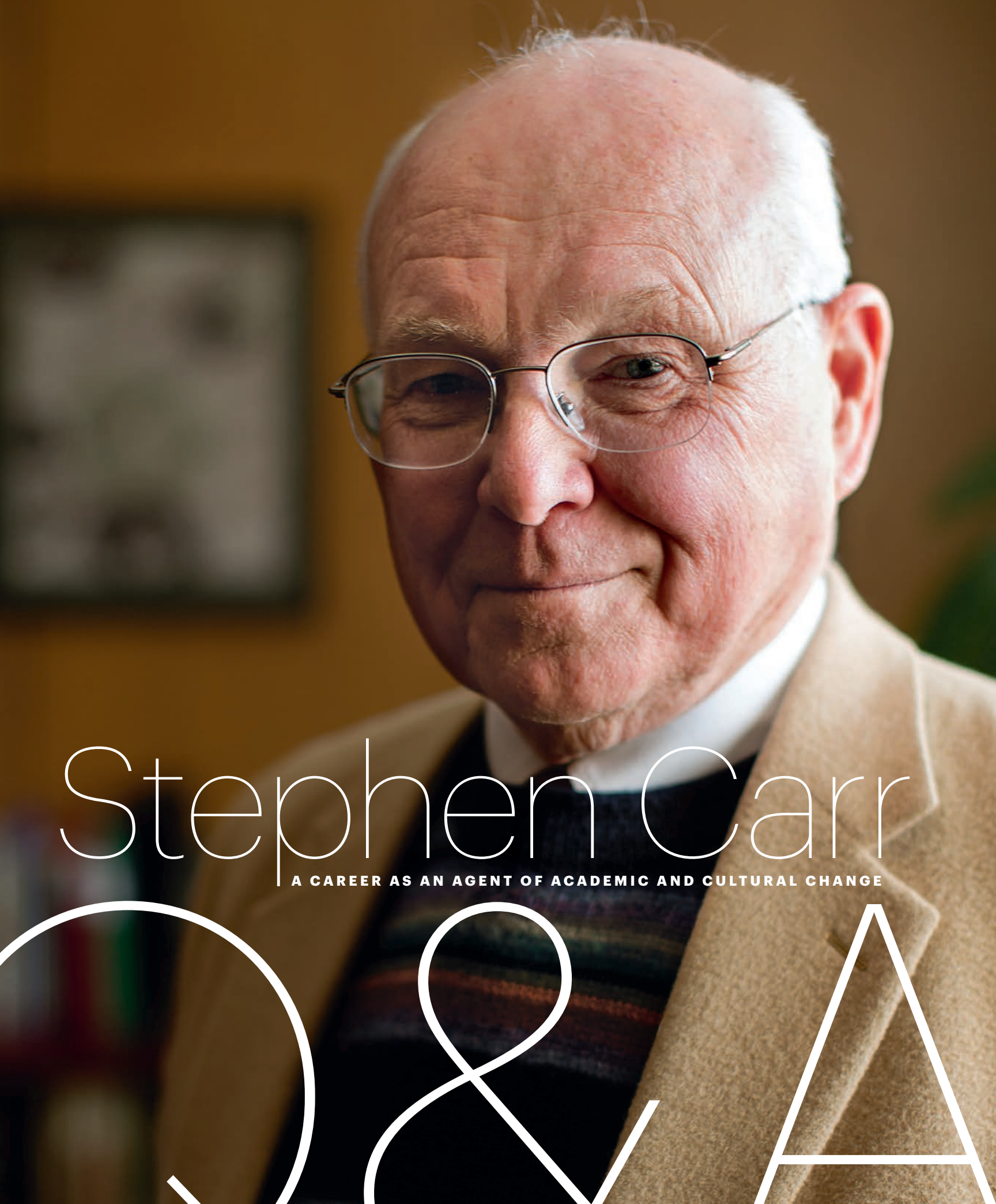
APPOINTMENT BOOKING PORTAL

Problem: Missed appointments. Because South Africa provides its citizens free access to healthcare, community health clinics often deal with long waiting lines, and patients must often accept appointments at times they cannot visit the clinic. The problem varies from clinic to clinic: at some, patients show up early in the morning, whether they have an appointment at that time or not, because they think they will be seen faster. At others, patients routinely miss appointments that are booked later in the day. At one of the clinics the students visited, none of the 20 patients booked for an 11 a.m. appointment showed up.

Solution: A booking app and kiosk. Students worked to create a tablet app that would guide patients through the steps of booking their next appointment at the time and date of their choice. That way, the patient would have more ownership of the appointment and perhaps would be more likely to show up. The tablet would be housed in a kiosk at the clinic for safekeeping.

Challenges: Technical literacy. Many of the people who visit the community health clinics are unfamiliar with touchscreens and common user interface conventions. After gathering user feedback, students changed the wording of the app's instructions to clarify how to use it.

Lessons Learned: Looking beyond the presented problem. Though healthcare workers asked for a booking portal, the team wondered if that would actually help alleviate the problem. "Would it be better if the healthcare workers booked future appointments at the end of their current appointment?" says Anna Rietti (biomedical engineering '15). "We're trying to figure out the real problem, not just go with the most obvious solution."



Stephen Carr

A CAREER AS AN AGENT OF ACADEMIC AND CULTURAL CHANGE

Q&A

He prefers not to take credit, but without Stephen Carr, McCormick would look quite different today. As senior associate dean of undergraduate engineering for the past 23 years, Carr has helped steer McCormick through a dramatic reimagining of the undergraduate curriculum and the emergence of a culture of whole-brain engineering. As he closes out his tenure in this position, Carr took time to reflect on how McCormick came to embrace the whole-brain concept, what he's enjoyed most as dean, and what he plans to do next.

What advances at McCormick stand out as most memorable during your tenure as senior associate dean?

Back in 1994, this was a research-intensive institution with a huge untapped potential to add engineering thinking and the full power of engineering to our education and culture. In the years since, we've accomplished much toward realizing that, most notably with Engineering First,® our overhaul of the undergraduate curriculum to embrace design thinking. This was the beginning of creating the culture that we would eventually call whole-brain engineering.

Revamping the curriculum sounds like a major endeavor. How did McCormick accomplish it?

Doing something as radical as overhauling the freshman curriculum was a bold move, but we weren't shy about the undertaking. Everyone really pitched in and carried their weight.

Of course, real change in the curriculum couldn't have happened if the dean didn't believe in it. Fortunately for McCormick, [former dean] Jerry Cohen embraced it, as did his successor John Birge, and our current dean Julio Ottino. We also needed the faculty to believe in it. I knew that if we empowered faculty to do what they really thought was important, they would go after it with surprising vigor, and they did. Overall, it took about 20 months to bring the proposed changes forward for approval. We finally rolled out Engineering First in 1997.

"ENGINEERING FIRST WAS THE DEFINITIVE OPENING STATEMENT OF A NEW ERA, WHERE A SMALL RESEARCH-INTENSIVE ENGINEERING SCHOOL COULD MAKE GREAT PROGRESS IN MANY AREAS." **STEPHEN CARR**

What else has changed at McCormick?

The curriculum, of course, has evolved over the years, but Engineering First was the definitive opening statement of a new era, where a small research-intensive engineering school could make great progress in many areas. And boy, have we! Since the curriculum overhaul, we've constantly stressed systematic and continuous improvement, believing that everything could be subject to radical revision, cancellation, or replacement.

Out of the curriculum changes, other accomplishments have arisen. Converting the co-op office into a comprehensive career development office, developing our Office of Personal Development, which was the first at any of the nation's engineering schools, and creating a full-service freshman advising center all stand out.

The Ford Motor Company Engineering Design Center is also a great manifestation of our cultural and programmatic change. Launching the Segal Design Institute and hiring individuals with a design focus have been pivotal in promoting engineering thinking. And the entrepreneurial spirit that we've seen flourish here has allowed engineering to have its full impact on the creative acts of human-centered design, inventiveness, and ingenuity.

What have you enjoyed most about serving in this role?

It's been thrilling to see so many of our students get fabulous jobs, either straight out from here or after having become established in their careers. Some students from 10 and 20 years ago are now appearing on the pages of *Forbes* and *Science* with their accomplishments. Others have become professors with great distinction. I love to see them realize—and appreciate—the opportunities that McCormick has made possible.

I've also worked with some great people. For a decade [professor] Ted Belytschko and I were once-a-week racquetball opponents at the Henry Crown Sports Pavilion and Norris Aquatics Center. We shared a vision for McCormick, but we also loved to goad each other on the racquetball court.

What's next for you? Will we still see you around McCormick?

Yes, I'll be teaching the materials selection course in the Department of Materials Science and Engineering. For the past 40 years, I have been committed to the field of materials science and to growing it through materials selection so it more directly informs and propels other engineering fields. It's a real opportunity area that's not been developed well enough.

I would also like to lead a larger effort to help engineers across the country learn materials selection; whether that will be through a Northwestern MOOC or webinar remains to be seen. And, I'll continue to teach the freshman Design Thinking and Communication course, and remain a member of several university committees, including One Book One Northwestern and the Taskforce on the Undergraduate Academic Experience.

You've witnessed a dramatic evolution at McCormick. What do you think the future holds for undergraduate engineering here?

We've undergone a significant cultural shift where our students and faculty now think on a much broader scale. It's no longer just national, now it's global. We're seeing the results of our intentional emphasis on creativity and expressiveness coupled with professionalism.

I'd prefer not to say a lot about the future of undergraduate engineering here. McCormick should control its own destiny. But, I think what we're doing is right, and nothing we're doing now will be obsolete or eclipsed over the next 30 to 40 years. We have a winning formula in place.

ALEX GERAGE

Photograph by Chris Strong

INSPIRING THE NEXT GENERATION

Before embarking on a full day of laboratory tours, design competitions, and hands-on experiments, more than 275 Chicago-area girls listened intently to words from Cindy Kent ('91) at McCormick's 44th annual Career Day for Girls. The president and general manager of 3M Drug Delivery Systems, Kent gave a keynote speech about her life and career as a female engineer. The popular event is designed to encourage young women to consider engineering in their education and career choices.

left Rendering of the Louis A. Simpson and Kimberley K. Querrey Biomedical Research Center

right JoAnne and Ronald Willens with Dean Julio M. Ottino

WE WILL.

THE CAMPAIGN FOR NORTHWESTERN

NORTHWESTERN UNIVERSITY'S MULTI-YEAR CAMPAIGN IS WELL UNDERWAY. TO LEARN MORE ABOUT 'WE WILL' AND THE CAMPAIGN PRIORITIES, VISIT WEWILL.NORTHWESTERN.EDU.

$92 MILLION GIFT STRENGTHENS CONNECTIONS BETWEEN MEDICINE AND ENGINEERING

Northwestern University Trustee and alumnus **Louis A. Simpson** (WCAS '58) and his spouse **Kimberly K. Querrey** have made an additional $92 million gift in support of the University's biomedical research programs at Northwestern's Feinberg School of Medicine. The new building will accommodate collaborative research conducted by McCormick, Northwestern Medicine's department of physical medicine and rehabilitation, and the Rehabilitation Institute of Chicago. The latest gift comes just a year after the couple made a $25 million gift to Northwestern to endow the Louis A. Simpson and Kimberly K. Querrey Institute for BioNanotechnology in Medicine, led by McCormick Professor Samuel I. Stupp (PhD '77).

$10 MILLION FOR NANO ONCOLOGY

A new $10 million gift from **Ronald** and **JoAnne Willens** ('81 P, '84 P, '11 GP, '15 GP) to Northwestern's International Institute for Nanotechnology will establish an interdisciplinary research center that will use advances in nanotechnology to develop new cancer treatments. The Willens Center will bring together nanoscientists, cancer biologists, engineers, and clinicians from three Northwestern schools: Weinberg, McCormick, and Feinberg. In 2011, the couple also gave a $10 million gift to advance nanotechnology research, naming the Willens Engineering Life Sciences Wing in the Technological Institute. Ron Willens is co-founder of the technology company Livingston Enterprises, which Lucent Technologies bought in 1997. JoAnne Willens is a retired technical illustrator.

NEW MAJOR GIFTS

Jack Dever ('51) established two endowed graduate fellows in electrical engineering with a $2.5 million bequest expectancy. Over the past two decades, Dever has also donated two endowed chairs in electrical engineering to McCormick. The John A. Dever Graduate Fellows will work alongside the John A. Dever Professor of Electrical Engineering and Computer Science. Dever is a dedicated member of the McCormick Advisory Council and the EECS Advisory Board.

Mary Meister ('98) and **Ethan Meister** gave a major gift to establish the Mary and Ethan Meister Endowed Summer Undergraduate Research Fellowships. This gift will provide materials science students with the opportunity to conduct original summer research alongside our world-class faculty. The Meisters have also supported the creation of a new undergraduate teaching lab in materials science. Mary is the Participation Co-Chair for the McCormick campaign.

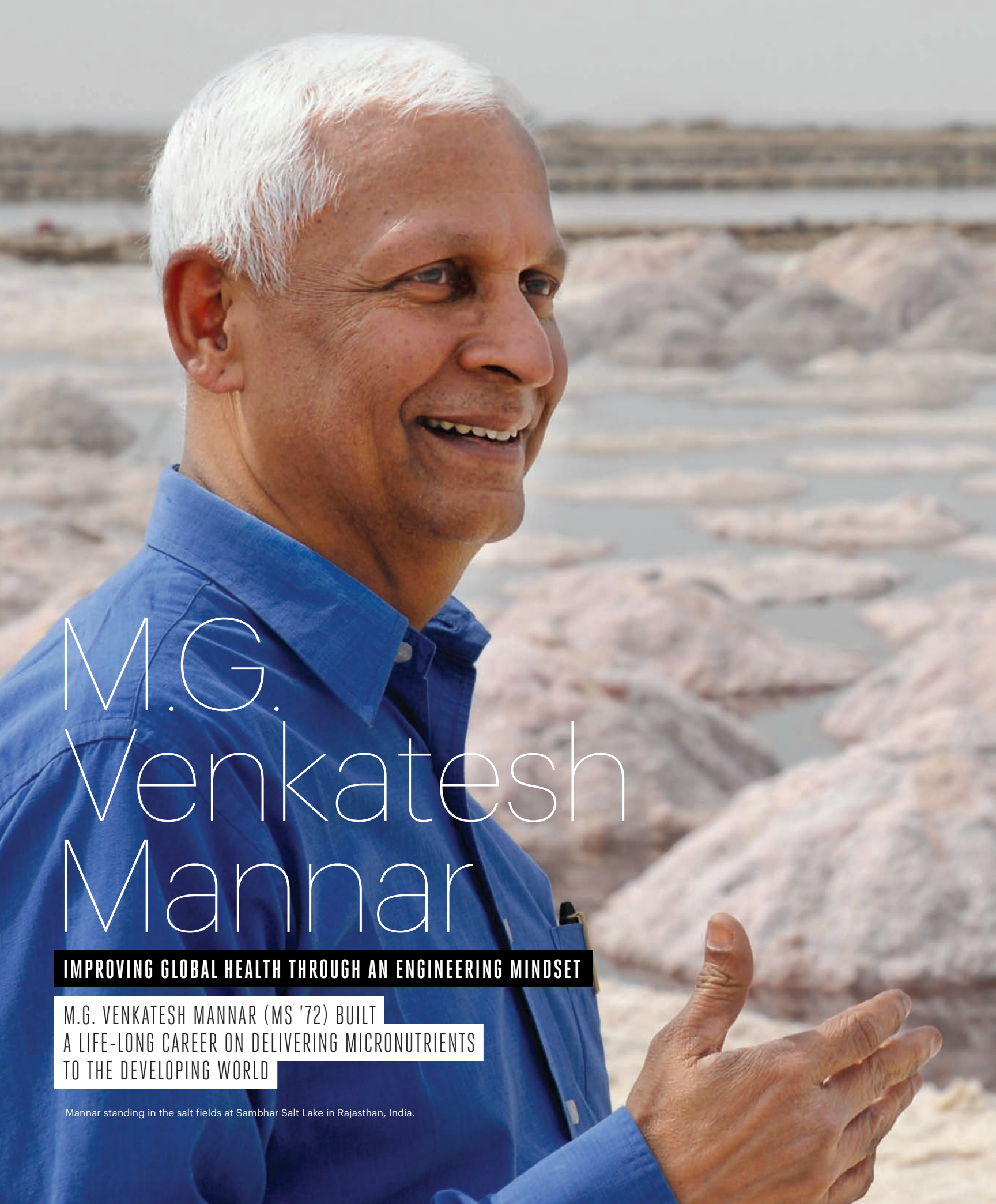
Paul Schipper (PhD '77) made a commitment of $100,000 to the Department of Chemical and Biological Engineering for an expendable graduate student recruitment fund, allowing the department to provide additional scholarship support for exceptional incoming graduate students.

McCormick alumna **Ilene Brostrom** gave $100,000 to endow the Ilene Brostrom '80 Endowed Fund for Undergraduate Research. This fund will fully support a student's summer research project and stipend each summer. Currently about 33 percent of McCormick undergraduates take advantage of the opportunity to do original research in our labs. With the help of Brostrom and other donors, this percentage is growing.

The following individuals have also made provisions for Northwestern University in their estates, specifically benefitting McCormick:

- **Bill Rosner** ('75, '76 KSM) and **Linda Rosner** of Pittsburgh, PA
- **Robert Phillips** ('63, PhD '72) and **Margaret Phillips** of Laurel, MD.

Thanks to these and thousands of other donors, McCormick has raised $99 million of its $200 million campaign goal to date.



M.G. Venkatesh Mannar

IMPROVING GLOBAL HEALTH THROUGH AN ENGINEERING MINDSET

M.G. VENKATESH MANNAR (MS '72) BUILT A LIFE-LONG CAREER ON DELIVERING MICRONUTRIENTS TO THE DEVELOPING WORLD

Mannar standing in the salt fields at Sambhar Salt Lake in Rajasthan, India.

When M.G. Venkatesh Mannar (MS '72) set out for the United States to get a master's degree in chemical engineering, he hoped to use what he learned to modernize his family's salt manufacturing business in India.

He earned the degree and something much greater than he could ever have imagined: an opportunity to make a positive difference in the health of some of the poorest, most vulnerable populations in the world.

"We had an opportunity in the early '70s to start looking at enriching salt," he remembers. "I was contacted by someone from UNICEF who said, 'There's iodine deficiency in many parts of the world—can you help us?' That's how I got involved in iodization of salt." What began with adding iodine—essential to brain development—to salt set Mannar on a 40-year career of reducing debilitating micronutrient deficiencies among the world's poorest and most vulnerable populations.

Mannar left the family business to become a consultant for UNICEF, the World Bank, and the World Health Organization, helping to establish salt iodization programs in more than 50 countries. Considered to be one of the most successful public health campaigns of the 20th century, the program today enables access to iodized salt for nearly four billion people. "I went to Bhutan, where there were very high levels of iodine deficiency in the early 1980s, to set up the first salt iodization plant with UNICEF," Mannar remembers. "Within two or three years of our distributing iodized salt to the population in that country, the problem—the goiters, the mental retardation caused by high levels of iodine deficiency—virtually disappeared.

Seeing similar dramatic improvements in health all around the world led Mannar to think bigger. "Because it's such a universally consumed condiment, I felt that we should look at other nutrients you can put into salt," he says. "Eventually I said, 'Why don't I give up my business interest, move full-time into this, and broaden it to adding nutrients to foods?'"

That desire to make a broader impact prompted Mannar and his family to move to Canada in the early 1990s, where he became president of the then newly formed Micronutrient Initiative (MI), a nonprofit organization dedicated to eliminating vitamin and mineral deficiencies around the world.

"At that time, there was a lot of interest in nutrition and micronutrients," he recalls. "The Canadian government was looking for someone to help take the organization forward, and it was just the right time at the right place."

During his tenure at the MI, Mannar spearheaded programs that continue to reach approximately 500 million people in more than 70 countries. Expanding beyond iodine to include vitamin A, MI has provided more than 75 percent of the vitamin A required for supplementation programs in developing countries since 1997. It's also working on programs to deliver zinc, iron, and folic acid, all vital to the growth and development of children.

One of the biggest obstacles to eradicating micronutrient deficiencies is simple lack of awareness of the problem, Mannar says. He has spent years meeting with heads of state to educate them about the issue.

"I ENCOURAGE ENGINEERS TO GET MORE INVOLVED IN PROBLEMS AFFECTING HUMAN DEVELOPMENT. MINE IS ONE EXAMPLE; THERE ARE MANY OTHER AREAS. I THINK THE APPLICATION OF ENGINEERING PRINCIPALS IS ABSOLUTELY KEY IN SOLVING MANY OF THE WORLD'S PROBLEMS, AND I FEEL THAT ENGINEERS HAVE A GREAT ROLE TO PLAY."

M.G. VENKATESH MANNAR

"This is an important problem that needs to be taken seriously at a very high level because it has a direct impact on human potential," he says. "A country that has severe deficiencies could lose several percentage points of its GDP. The solutions are very cost-effective—if you invest a dollar in fortification, you get back $30 to $40 in terms of improved human health, better productivity, and mental and physical development in children."

For Mannar, the work has been a tremendous effort for an even greater reward. "Seeing the huge number of people we've been able to reach through these programs—we estimate nearly half a billion people directly benefit from the work we have done—and knowing that it can be sustained permanently is great."

Mannar recently retired from MI, but continues to work towards the elimination of micronutrient deficiencies through a range of food-based solutions driven by cutting-edge technologies. He serves as an adjunct professor at the University of Toronto and is a visiting faculty member at Cornell University. His achievements on behalf of humanity were honored with an appointment as Officer of the Order of Canada, one of the country's highest civilian honors. He says he was able to embark on such a career thanks to the valuable chemical engineering principles and lessons he learned at McCormick.

"McCormick provided me with the foundation for all of my work," he says. "In most of the courses, there were no ready-made answers to any of the questions. My engineering education forced me to think on my own and gave me an ability to analyze problems at a broad level."

He hopes fellow engineers will also apply what they know to help solve some of the world's biggest humanitarian issues. "I encourage engineers to get more involved in problems affecting human development," he says. "My career is one example; there are many other areas where engineers can contribute. I think the application of engineering principles is absolutely key in solving many of the world's problems, and I feel that engineers have a great role to play."

SARA LANGEN

CLASS NOTES

1950s

John A. "Mac" McQuown ('57), principal at Diversified Credit Investments, LLC, was profiled in *Bloomberg Markets* regarding a new corporate bond derivative he and fellow business partners are developing.

Thomas E. Reimer ('59, '86) published his latest novel, *The Know Nothings* (Virtualbookworm.com, 2014), the fourth book in his "Wild Onion Saga." The story continues the tale of mid-19th century immigrants Axel Konrad and Seamus O'Shea.

1960s

George P. Nassos (MS '62, PhD '65) published his first book, *Practical Sustainability Strategies: How to Gain a Competitive Advantage*. In November 2014, he was presented with the Lifetime Hellene Award by the Hellenic Bar Association of Illinois for his dedication to protecting the environment.

James Funk ('66) published his novel *Long Walk Home*, which chronicles a Civil War infantry soldier's love story.

Alan F. Karr ('69, MS '70, PhD '73), director of the National Institute of Statistical Sciences, was appointed director of the Center of Excellence for Complex Data Analysis at RTI International.

1970s

Alan Zagoria ('74), an engineering fellow at UOP, retired after 40 years. Earlier this year, he received the Ernest W. Thiele Award from the American Institute of Chemical Engineers for contributions to the profession.

Allyn Rifkin (MS '75) was re-appointed commissioner to the Marina del Rey Harbor Commission and is now serving as its chairman. He spent the previous 34 years with the Los Angeles Department of Transportation.

Maximillian D. Fiore ('77), senior vice president and chief technology officer at American Medical Systems, was appointed chief development and operations officer at NxThera Inc., a medical device company focused on providing solutions to treat endourologic conditions.

1980s

Michael Apkon ('82), president and chief executive officer of the Hospital for Sick Children in Toronto, Canada, was appointed to the hospital's board of directors.

Robert Sinn ('82), a principal and structural engineering practice leader at international engineering firm Thornton Tomasetti, has been elected a fellow of the American Concrete Institute.

Helen S. Kim ('85), special adviser to NGM Biopharmaceuticals, was appointed to the board of directors at AuraSense Therapeutics.

Kevin H. Glynn ('86) was appointed chief information officer at DSC Logistics.

Claudia Levy Grandjean (MS '88) was appointed chief operating officer at US Tele-Medicine.

Steven M. Gonzalo ('89), executive vice president and chief technology officer at The First National Bank of Ottawa in Ottawa, Illinois, was promoted to president and chief executive officer.

Kurt B. Thaus (MEM '89), senior vice president and chief information officer at Telephone & Data Systems Inc., was appointed to the board of directors at U.S. Cellular.

1990s

Alicia S. Boler-Davis ('91), senior vice president of global quality and customer experience at General Motors, was awarded the 2014 Technologist of the Year distinction by *Women of Color* magazine.

Mark Howard Orttung (MS '91) was appointed chief executive officer at Nexient, a provider of enterprise technology consulting. He was previously president and chief operating officer at Bill.com, an automated payables and receivables company.

Kathleen A. Neumann (PhD '92), associate provost for budget, planning, personnel, and technology at Western Illinois University, was appointed interim dean of the university's College of Business & Technology.

Gregory J. Santoro (MEM '92; KSM '92) was appointed chief marketing and strategy officer at the National Rural Telecommunications Cooperative. He previously served as chief marketing and strategy officer at NII Holdings, Inc.

Eileen Ann Sweeney-Tan (MEM '93; KSM '93), vice president and general manager at CSC, was appointed senior vice president and general manager of Iron Mountain's data management business.

Ryan Allen Buxton ('94), internal audit manager in commercial banking at JPMorgan Chase, was appointed a trustee of the Village of Steger, Illinois.

Matthew Levatich (MEM '94; KSM '94) was promoted to chief executive officer at Harley-Davidson Motor Company. He was previously the company's president and chief operating officer.

Douglas G. Albert (MEM '96; KSM '96) was appointed president and chief executive officer of Resco Products, a producer of refractory solutions.

Robert Malone (MEM '96; KSM '96) was promoted to vice president and president-filtration group at Parker Hannifin Corporation after previously serving as the group's vice president of operations.

Lance A. Donenberg (MEM '97; KSM '97) was appointed principal and head of strategic business development at Evanston Capital Management, LLC.

Douglas J. Peters (MPM '98) was promoted to executive vice president at Christman Constructors, Inc.

2000s

Jeff Kristick (MEM '00; KSM '00) was appointed president of Meridian Knowledge Solutions, a provider of enterprise, web-based learning management software. He was previously vice president of the HCM business unit at Oracle.

Brett A. Bernstein (MS '01; WCAS '96), vice president of data operations and project management at Centro, was appointed vice president of technology at Outsourced Ad Ops.

Peter M. Babaian, Jr. (MS '02), associate principal at Simpson Gumpertz & Heger, was promoted to building technology division head at the firm's Chicago office.

Clinton Kent (MEM '03; KSM '03) was promoted to vice president, sales and customer service for components, at StandardAero.

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IN MEMORIAM

Prof. William M. Smedley '38
Mr. Thaddeus N. DeWolf '41
Mr. Alexander G. Edeleanu '42
Mr. Donald R. Diggs, PhD '44
Mr. Robert P. Gleason '44
Mr. Edward W. Ruehrwein '44
Mr. Edwin A. Trenkle '44
Mr. Joseph J. Backor '45
Mr. James R. Fay, Sr. '45
Mr. William L. Morrison '45
Mr. William E. Hill '46
Mr. John J. Gallagher '47
Mr. Elmer N. Lenk '48
Mr. Lloyd L. Pelling '48
Mr. Frederick A. Thulin, Jr. '48
Mr. George J. Gonwa '49
Mr. Louis F. Lemond '49
Mr. George A. Parry '50
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Mr. Ned H. Wuellner, PhD '51
Mrs. Jane K. Hodge '52
Mr. Earl J. McLean '52
Mr. Robert M. Arthur '53
Mr. Robert A. Payne '53
Mr. James R. Lancaster '55
Mr. Paul J. Clymer '56
Mr. Gerald A. Florence '57
Mr. Henri P. Caldwell '58
Mr. Ralph C. McElvain '58
Dr. Charles Chiou '59
Dr. K. Bruce Isom '61
Mr. James A. Morton, III '63
Mr. Gary W. Muther '66
Mr. Lowell B. Anderson '68
Mr. John L. Stump '69
Mr. Carl Leroy Carter '71
Dr. Joseph K. Shartiag '71
Mr. John C. Roth '72
Mr. Richard Martin Houston '80
Mr. George Beranek, Jr. '89
Mr. Kenichi Shimokogawa '92
Ms. Irene Kay Haque Michels '11

HE JUST DOES IT

HOW **BRIAN FLUCHT** ('98) HELPS DRIVE CORPORATE AND BUSINESS DEVELOPMENT AT NIKE

Brian Flucht ('98) began his education at Northwestern in the fall of 1994 with a biomedical engineering major and visions of becoming a doctor. Four years later, Flucht graduated from McCormick with a degree in materials science and engineering, trading the pursuit of a medical career for a job with the National Security Agency (NSA).

"I did some very cool things at the NSA," says Flucht, and adds, "but unfortunately nothing I can discuss."

One aspect of his tenure at the NSA that Flucht does freely discuss is the versatility of his engineering degree. "I began to see how my training as an engineer could be used in so many other ways," he says.

This realization took the southern California native down a once-unforeseen path: first to an MBA, then on to venture capital, and finally into Nike's global headquarters near Portland, Oregon, where he now serves as director of global corporate business development.

When Flucht first arrived at Nike, one of the world's most iconic and forward-thinking brands, he joined the company's Sustainable Business and Innovation Lab, which discovered and supported pioneering innovations, particularly with outside vendors. A couple of years later, he was asked to join Nike's new global corporate business development team, where he interacts with senior leadership and helps drive strategic partnerships.

"I'm fortunate that I've been able to see how the entire machine works through a unique lens," says Flucht, a fitness devotee who calls himself an authentic Nike brand champion.

Focusing specifically on Nike's direct-to-consumer digital commerce, retail, brand, and consumer technology businesses, Flucht and his teammates serve as the connective tissue between the company's consumer IT and business leadership.

"When you're navigating those two highly distinct worlds, being tech savvy and having an engineering background definitely helps put things in perspective," Flucht says.

The engineering mentality comes into play especially when he encounters a challenging issue around an investment, product innovation, or other business-driving move. Flucht says his academic training as an engineer helps him shed distractions and pursue solutions.

"Because of my education at McCormick, I've learned how to ask the right questions and get to the root of a challenge to find the opportunity," he says. "In a company always looking to be at the forefront, that focus is incredibly important."

DANIEL P. SMITH

"BECAUSE OF MY EDUCATION AT MCCORMICK, I'VE LEARNED HOW TO ASK THE RIGHT QUESTIONS AND GET TO THE ROOT OF A CHALLENGE TO FIND THE OPPORTUNITY."

"I learned a tremendous amount just being around incredibly intelligent and hard-working people. That applies every day, because now in the business world, I want to keep that incredibly high standard in everything I do and in the interactions I have with people at work."

Closing the skills gap, furthering careers

JONATHAN FRIEDMAN (MS '14) CONNECTS JOB SEEKERS WITH FREE ONLINE EDUCATION THROUGH ENTREPRENEURSHIP AND COLLABORATION.

Using computers to solve human problems. That's what drew Jonathan Friedman (MS '14) to computer science.

"The idea of building things that helped people or made their lives easier was really cool to me," he recalls. "I was in school at the time, and I thought, 'If there are so many problems in the world that need to be solved, I should just start solving things.'"

Not one to wait around for change, Friedman connected with fellow Northwestern student and now business partner Daniel Daks, and the two launched several business ventures that culminated in TradeUp.io, an adaptive learning platform that helps job seekers by matching their skills to jobs and linking them to free online training courses.

They got the original idea from Daks' own struggle as a Northwestern student trying to learn how to code. "Daniel was finding it really difficult to teach himself how to program," Friedman says. "We thought if that was his experience, someone else had probably experienced it, too. So we just jumped in."

In 2013, with funding through the DreamIt Ventures NYC start-up accelerator program, the two developed an idea they thought would help job seekers and employers close the skills gap. Within months of launching TradeUp, the site was acquired by Apollo Education Group, a leading provider of higher education programs for working adults.

Apollo merged TradeUp with one of its existing properties, SkilledUp Academy (Academy.Skilledup.com). Today, Friedman works with Apollo as senior software engineer and NYC office lead for Academy.Skilledup.com, which now incorporates many of the concepts behind TradeUp, particularly its emphasis on mentored learning. He runs the engineering team while partner Daks oversees product for the newly revamped site.

"We took what we learned around the mentorship, the curriculum, and the personalization we had at TradeUp and really focused it down," he explains. "We rely a lot less on algorithms to provide services and lot more on humans."

Although computer science is often viewed as a solitary pursuit, it was the collaboration with fellow students that made Friedman's McCormick experience one that continues to enrich his work today. "I learned a tremendous amount just being around incredibly intelligent and hard-working people," he shares. "That applies every day, because now in the business world, I want to keep that incredibly high standard in everything I do and in the interactions I have with people at work."

SARA LANGEN

ANOOP JAIN A LIFE'S WORK IMPROVING LIVES

ANOOP JAIN ('09) TAKES PERSONAL RESPONSIBILITY FOR INNOVATIVE SOLUTIONS TO SANITATION PROBLEMS IN INDIA

Indoor plumbing and working toilets—conveniences that so many take for granted—remain a rare luxury in much of the developing world. For example, more than 650 million people in India lack adequate indoor sanitation facilities, forcing them to defecate outdoors, exposing the population at large to 100,000 tons of untreated human waste annually, and contributing to the spread of diseases that kill 450,000 each year.

Anoop Jain ('09) finds these numbers unacceptable. During a trip to India in 2010, he visited Bihar, one of the poorest states in the country. Shocked by the discovery that in the 21st century millions still did not have access to toilets, he founded Humanure Power, a not-for-profit enterprise that constructs community toilet facilities to decrease defecation outdoors.

Humanure Power has focused its efforts in the remote and isolated Supal district of Bihar, where 1.3 million people defecate outdoors daily. The group opened its pilot community sanitation facility in July 2014. It serves 750 people per day and disposes of tons of waste each month.

"We wanted to concentrate our effort in one area," says Jain, who studied environmental engineering at McCormick. "I plan to spend the rest of my life doing this work, and we still won't entirely eliminate outdoor defecation. It's a tremendous battle."

In September 2014, Jain received the Waislitz Global Citizen Award, which awards $100,000 annually to a single individual based on four key criteria: global citizenship, impact, innovation, and potential to continue work. With these funds, Humanure Power will construct three more facilities in Bihar.

True to his innovative spirit, Jain's next step is to redefine waste and treat it as a resource. When bacteria break down human organic waste, they produce methane gas, which can be used as energy. Jain's team is about to install a system that uses methane to power water filters, which he predicts could produce 2,000 liters of clean water per day and be sold for a small fee to help maintain the facilities.

"We are using technology that has already been proven to work," Jain said. "We didn't want the community to be our guinea pigs."

AMANDA MORRIS

LIFE AT THE INTERSECTION OF ENGINEERING AND LAW

After helping engineer a highly successful medical industry spinoff, **Joan Stafslien** ('87) readies for her next challenge.

In 2008, as senior vice president and general counsel for Cardinal Health's clinical and medical products business, Joan Stafslien ('87) began the process of spinning off that division into a publicly traded company, one that would rapidly emerge as a major medical technology industry player. It was an effort that would call upon her engineering background and ultimately change her life.

Over 13 months, Stafslien, a McCormick chemical-engineering-major-turned-attorney, led a team that crafted the governance structure, negotiated the spin-off transaction documents, and established the company's debt structure. "The spin-off needed to be a viable entity from day one," Stafslien notes.

Describing the challenge, she says, "Engineering and law aren't that different. One's numbers, and the other is words and legal principles. Both are fundamentally about dissecting, analyzing, and resolving issues—and when you're creating something wholly new, it takes a lot of problem solving."

Stafslien recalls time spent as an undergraduate investigating complex classroom problems in the office of engineering professor John Torkelson. "That's really where I learned how to set and work through challenging questions," she says.

The spin-off was completed in September 2009, and Stafslien assumed the role of executive vice president, general counsel, and corporate secretary for the resulting enterprise, CareFusion. "That I was an engineer and could understand the science side of our business was vitally important," says Stafslien, who navigated the complexities of the company's high-tech work, diving in alongside clinical, operations, and R&D staff to tackle the legal issues inherent in the highly regulated healthcare industry.

Over its first five years, CareFusion grew into one of the world's leading providers of medical technology. As is often the case with surging, first-rate companies in the fast-evolving healthcare universe, CareFusion attracted the eyes of suitors. In October 2014, Becton, Dickinson and Company, a major global medical technology company, signed a deal to acquire CareFusion for $12.2 billion.

Reflecting on the deal, which closed in early 2015, and contemplating her future, which may include board work, Stafslien says, "We not only brought hospitals life-sustaining equipment, we also helped reduce medication delivery errors and infections. It was important, even life-changing work, and I feel that experience will always be an asset wherever I choose to go. I know I have much more to give."

DANIEL P. SMITH

"ENGINEERING AND LAW AREN'T THAT DIFFERENT. ONE'S NUMBERS, AND THE OTHER IS WORDS AND LEGAL PRINCIPLES. BOTH ARE FUNDAMENTALLY ABOUT DISSECTING, ANALYZING, AND RESOLVING ISSUES—AND WHEN YOU'RE CREATING SOMETHING WHOLLY NEW, IT TAKES A LOT OF PROBLEM SOLVING."

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Fundamentals of Digital Image and Video Processing, taught by Aggelos Katsaggelos, AT&T Professor of Electrical Engineering and Computer Science.

Digital images and videos are everywhere, dominating thousands of scientific, consumer, industrial, and artistic applications. The ability to process image and video signals, therefore, is an increasingly important skill to acquire. Participants in this class will learn the fundamentals of image and video processing, including the theory behind them and the skills to perform key processing tasks using state-of-the-art techniques and tools.

Everything is the Same: Modeling Engineered Systems, taught by Todd Murphey, associate professor of mechanical engineering and physical therapy and human movement sciences.

A "systems" view focuses on what is common to different parts of physical systems. By viewing the world through this lens, scientists and engineers have made stunning advances in aeronautics, robotics, and other disciplines where many different technologies work together. Starting with basic algebraic descriptions of individual components, students will learn how to develop the tools for modeling engineered systems. A familiarity with high school calculus is required.

How Green is that Product? An Introduction to Life Cycle Environmental Assessment, taught by Eric Masanet, Morris E. Fine Junior Professor in Materials and Manufacturing.

Paper or plastic? Local or imported food? Which is better for the environment? To answer these questions, one must take a holistic systems approach known as life-cycle assessment (LCA), a fundamental method for assessing environmental impacts of products and technologies from "cradle to grave." Course participants will emerge with a solid understanding of the importance of the LCA perspective, basic skills for applying the method and interpreting its results.

Power Onboarding, taught by William White, professor of industrial engineering and management sciences.

Research shows that actively preparing for a new job helps employees reach efficiency and exceed workplace expectations at a much faster rate. In a six-session format, Power Onboarding will provide practical tools for individuals transitioning into new jobs. Throughout the course, participants will learn how to create their own personalized onboarding plans. The course applies to people at all career stages.

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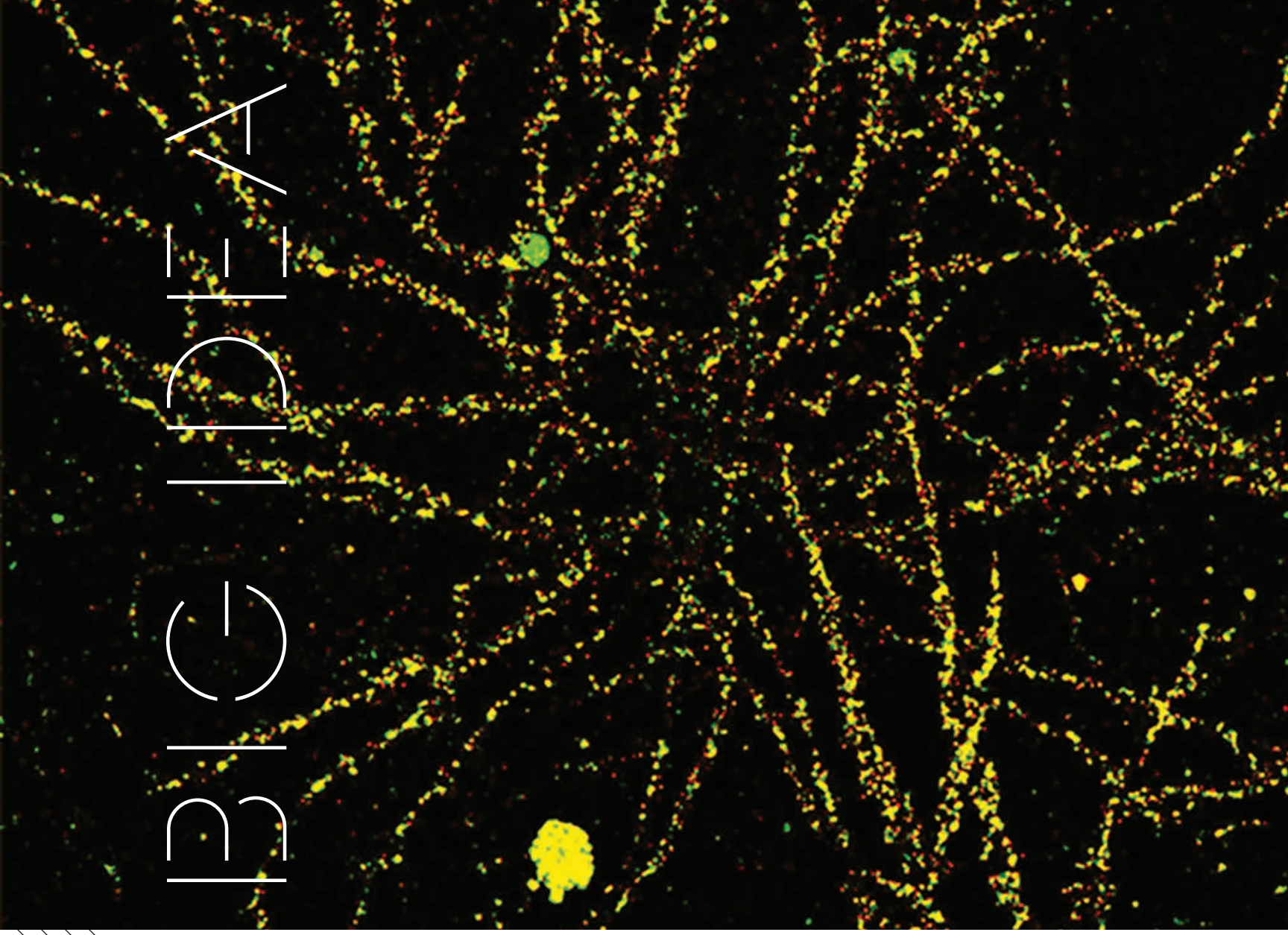

DETECTING ALZHEIMER'S AT ITS ONSET

Alzheimer's disease affects one out of every nine people over the age of 65. But without a means of early detection, nothing can be done to slow its devastating progression. Now, an interdisciplinary team of Northwestern scientists and engineers has developed a noninvasive MRI approach that can detect the disease in a living animal. And it can do so at the earliest stages of the disease, well before the typical symptoms appear.

Led by neuroscientist William L. Klein and materials scientist Vinayak P. Dravid, the research team developed an MRI probe that pairs magnetic nanostructures with an antibody to seek out the amyloid beta brain toxins responsible for the onset of the disease. With the associated magnetic nanostructures, the accumulated toxins show up as dark areas in the MRI scans of the brain.

Conventional Alzheimer's diagnostics technologies look for plaques, which occur at a stage of Alzheimer's when therapeutic intervention is often too late. Klein and Dravid's approach instead detects toxic amyloid beta oligomers, which appear more than a decade before plaques. These oligomers attack the synapses of neurons, destroying memory and ultimately resulting in neuron death. As time progresses, the amyloid beta builds up and sticks together, forming the plaques that current probes target.

"Using MRI, we can see the toxins attached to neurons in the brain," says Klein, who first identified the amyloid beta oligomer in 1998. "We expect to use this tool to detect this disease early and to help identify drugs that can effectively eliminate the toxin and improve health."

The ability to detect these toxins may one day enable scientists to spot warning signs earlier and better design drugs or therapies to combat a disease for which there are no effective drugs.

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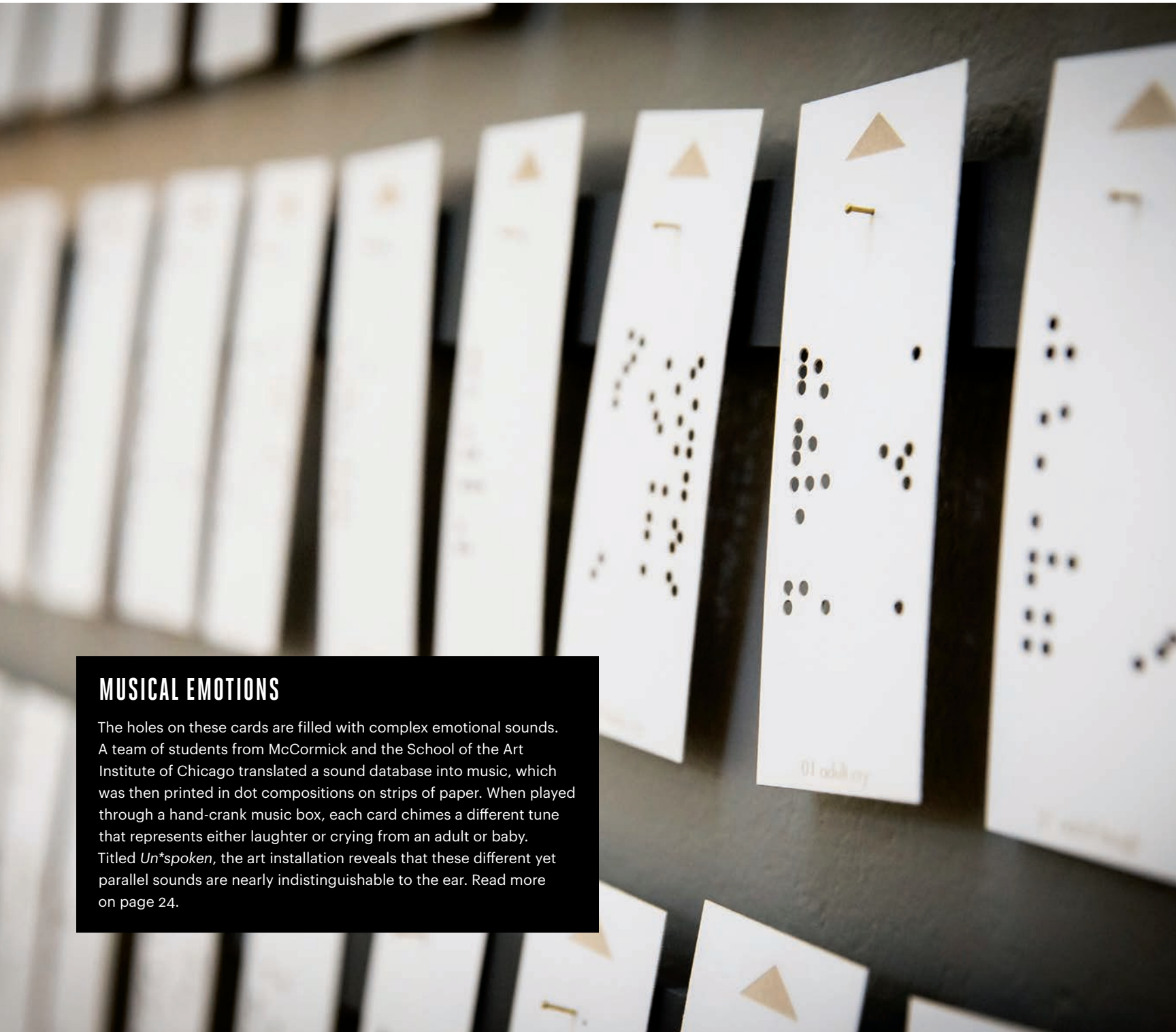

MUSICAL EMOTIONS

The holes on these cards are filled with complex emotional sounds. A team of students from McCormick and the School of the Art Institute of Chicago translated a sound database into music, which was then printed in dot compositions on strips of paper. When played through a hand-crank music box, each card chimes a different tune that represents either laughter or crying from an adult or baby. Titled *Un*spoken*, the art installation reveals that these different yet parallel sounds are nearly indistinguishable to the ear. Read more on page 24.