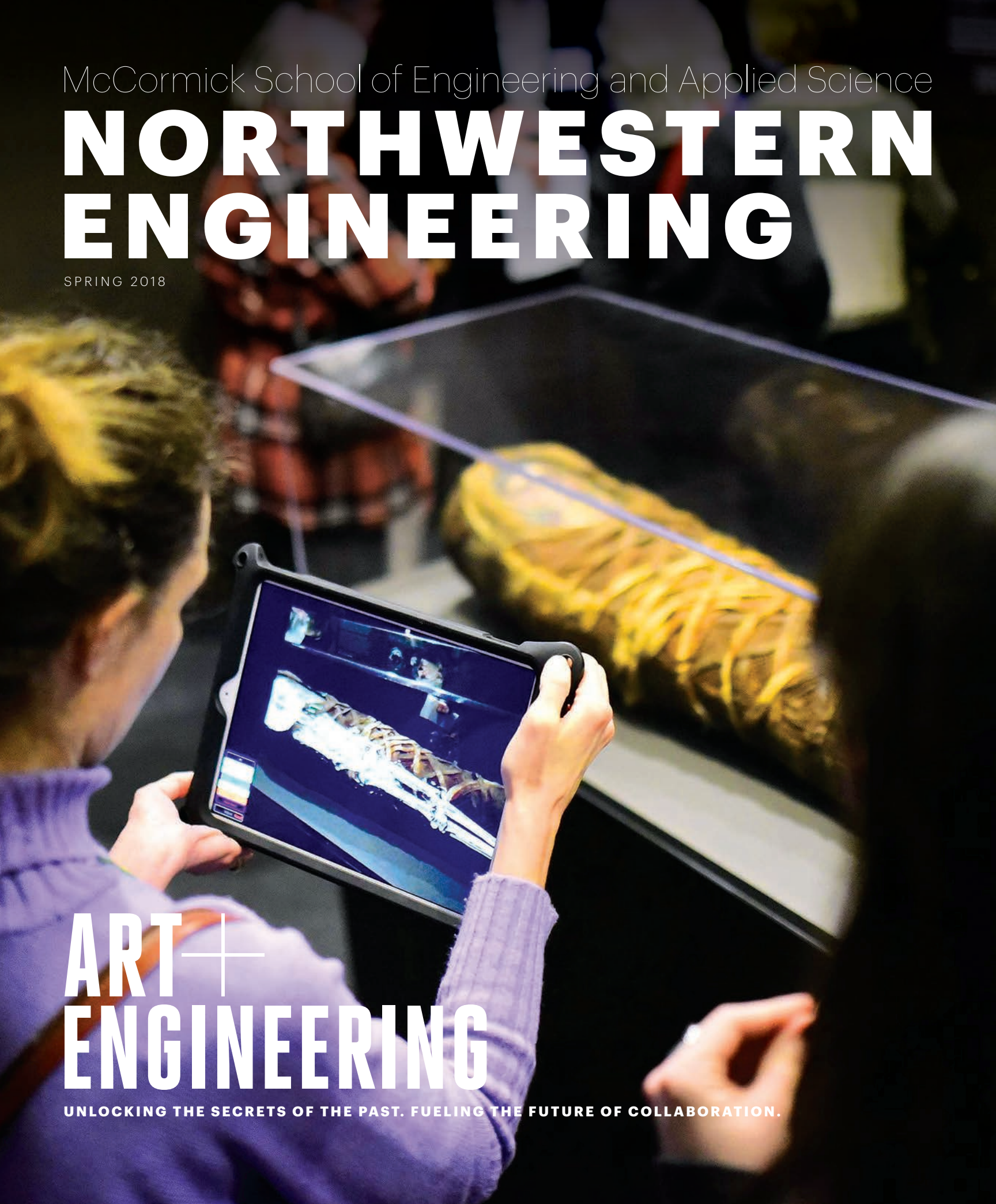


McCormick School of Engineering and Applied Science

NORTHWESTERN ENGINEERING

SPRING 2018



ART + ENGINEERING

UNLOCKING THE SECRETS OF THE PAST. FUELING THE FUTURE OF COLLABORATION.





SOUNDSCAPE

How might a fleeting musical performance create a sense of place for residents in a large city? As part of Data as Art, a course in which students from Northwestern Engineering and the School of the Art Institute of Chicago work in teams to create art from datasets, one team created Sound Lines, an artistic installation that depicted live music performances across Chicago. Visitors to the exhibit in the Ford Motor Company Engineering Design Center this winter could interact with the installation by flipping switches to illuminate panels representing musical genres and the neighborhoods where music was performed.

Photograph by Justin Barbin



NORTHWESTERN IS ONE OF THE FEW PLACES WHERE UNUSUAL PARTNERSHIPS BETWEEN DISCIPLINES ARE NOT ONLY POSSIBLE, BUT ENTHUSIASTICALLY EMBRACED.

GREETINGS FROM NORTHWESTERN ENGINEERING

One great pleasure over the past several years leading Northwestern Engineering has been the development of new initiatives to connect different disciplines. One of our most successful has been at the interface of art and engineering. Northwestern is one of the few places where unusual partnerships between disciplines are not only possible, but enthusiastically embraced.

Though art and engineering are considered two different fields in today's academic setting, it is only recently that they became separate domains. My colleague Adrian Randolph, dean of the Weinberg College of Arts and Sciences, and I recently wrote about one famous landmark that continues to serve as an example of the power of interdisciplinary thinking: the Brunelleschi dome in Florence, Italy.

Precisely 500 years ago, the city of Florence held a design competition for a dome for its unfinished cathedral. After winning the commission, Filippo Brunelleschi not only had to tackle aesthetic and engineering problems but also invent and construct machines for transporting and maneuvering materials. The result was spectacular: the first octagonal dome in history built without a temporary wooden supporting frame.

In addition to being known for the dome, Brunelleschi performed optical-geometrical experiments that were pivotal in the development of systematic linear perspective and also wrote poetry,

designed settings for theatrical performances, and broke new ground in the field of sculpture, painting, architecture, and engineering.

He was amazing, but there were many like him. He died six years before Leonardo da Vinci was born. How could a city of 60,000 people produce so many people who felt at home in multiple domains? This was a time when there were fewer defining boundaries and art, science, and technology were seen as one.

In many of my talks and opinion pieces, I have joined colleagues in calls for reconnecting these disciplines. Our partnership with the Block Museum of Art is an ideal catalyst for this. As you will read in this issue, this partnership has resulted in visiting interdisciplinary artists and an exhibition that perfectly exemplifies these ideas. The partnership is just one of many collaborations within Northwestern and with outside partners designed to create opportunities for different disciplines to collide. These experiences help our students and faculty expand their thinking skills, unlocking new avenues for discovery and innovation.

As always, I welcome your feedback.

JULIO M. OTTINO
Dean, McCormick School of Engineering and Applied Science

On the Cover

Visitors got an inside view of a 2,000-year-old mummy this spring at the Block Museum. Read more on page 14.

Image courtesy of the Block Museum.

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BACK TO NATURE FOR A PURE POUR

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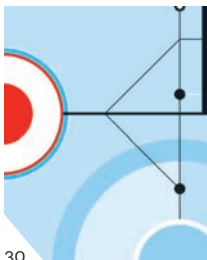
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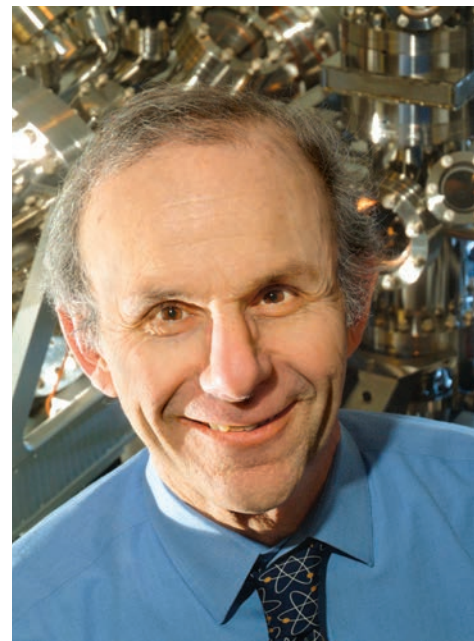
DAVID SEIDMAN ELECTED TO NATIONAL ACADEMY OF ENGINEERING

David N. Seidman, whose work has led to an improved understanding of materials on the atomic scale, has been elected to the National Academy of Engineering (NAE), one of the highest professional distinctions accorded to an engineer.

Seidman was cited by NAE for “contributions to understanding of materials at the atomic scale, leading to advanced materials and processes.” He is one of 83 new members and 16 foreign members and will be formally inducted during a ceremony at the NAE’s annual meeting on September 30, 2018, in Washington, D.C.

Seidman is a Walter P. Murphy Professor of Materials Science and Engineering and the founding director of the Northwestern University Center for Atom-Probe Tomography, the largest atom-probe tomography group in the United States.

Seidman’s research group uses highly sophisticated microscopy and spectroscopy instrumentation to study interfaces on a subnanoscale level to better understand the materials’ properties. The group also uses these tools to develop new alloys for turbine blades in aircraft and for producing electricity, and to study silicon nanowires that are processed in new ways.



LUCIA BRUNEL RECEIVES 2018 MARSHALL SCHOLARSHIP

Senior Lucia Brunel has received a 2018 Marshall Scholarship to attend the University of Cambridge this fall to pursue a master of philosophy degree in materials science and metallurgy. Designed to train future leaders, the Marshall Scholarship promotes partnerships, peace, and greater understanding among Britain, Ireland, and the United States. Brunel has conducted research since 2013, when she was a high school senior working in a biomaterials lab. At Northwestern, she continued her research path as a member of Professor John Torkelson’s laboratory.

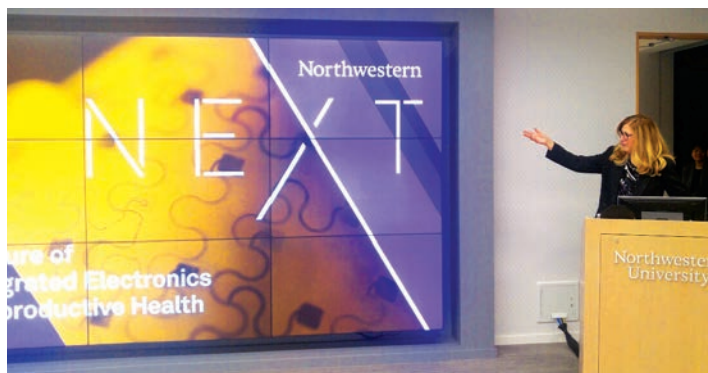
40

Number of students who participated in a 48-hour hackathon to develop data analytics solutions to aid humanitarian efforts in natural disasters



10TH

Anniversary this year of ETOPiA: Engineering Transdisciplinary Outreach Project in the Arts, an initiative that inspires cross-disciplinary dialogue about the role of science and technology in society



TECH STARTUPS SHOWCASE FUTURE OF HEALTHCARE

Ten Northwestern University startups and two engineering professors showcased their innovative medical solutions in January 2018 at a Northwestern reception coinciding with a major healthcare conference in San Francisco.

More than 150 people attended “The Future of Biointegrated Electronics and Reproductive Health” to learn about Northwestern’s innovative startups in therapeutics, diagnostics, and devices and to hear keynote addresses by Professors John Rogers and Teresa Woodruff.

Among the featured startups were Aptinyx, a clinical-stage biopharmaceutical company that discovers and develops therapies for disorders that affect the brain and nervous system; Epicore Biosystems, which develops soft, skin-mounted microfluidic devices that harvest and route sweat from skin pores to monitor human physiology and biochemistry; and Excicure, a clinical-stage biotechnology company that develops a new class of immunomodulatory and gene-regulating drugs to address inflammatory diseases, genetic disorders, and cancer.



“DATA AS ART SHOWED ME HOW SOMEONE FROM A MIX OF ENGINEERING AND HUMANITIES BACKGROUNDS CAN CONTRIBUTE TO THE ARTISTIC PROCESS.”

ANN YU

SENIOR DOUBLE-MAJORING IN PHILOSOPHY AND COMPUTER SCIENCE



DATA AS ART COURSE EXPLORES LIVE MUSIC, GOVERNMENT SPENDING, AND DREAMS

How might a fleeting musical performance create a sense of place for residents in a large city? Students from Northwestern Engineering and the School of the Art Institute of Chicago (SAIC) created a soundscape to illustrate one possible answer. Sound Lines, an artistic installation that depicts live music performances across Chicago, was one of five projects included in an exhibition celebrating Data as Art, a fall course jointly led by faculty from both schools.

During the course, students formed interdisciplinary teams, conducted research using data sets, and then represented that data through visual art. Supported by the Barry and Mary Ann MacLean Fund for Art & Engineering, the course provides new opportunities for art and engineering students to enhance the way they see, perceive, and interact with the world.

“The studio environment and the construct of learning through self-exploration is often something new for the Northwestern Engineering students, but it is central to the approach at SAIC,” says Jim Wicks,

clinical associate professor in the Segal Design Institute, who co-taught the course. “It can be high risk in terms of the quality of the artistic outcome and be, at the same time, a highly valuable learning experience for the students.”

Other exhibited projects from this year’s course included Big Money, a sculptural installation that uses augmented reality to visualize the history of government spending, and Homo Somnum, an LED display based on data collected from the brain activity of sleeping students.



GRADUATE STUDENTS CELEBRATE COMMENCEMENT

On December 9, 2017, 239 master’s students and 13 PhD students celebrated their graduation. The ceremony featured remarks by tech entrepreneur Rich Padula (’84), founder of Syclo and Deep Dish Technology. Padula emphasized the importance of building a positive workplace culture. He outlined three key attributes that contribute to a healthy culture: bringing the right attitude, being empathetic, and accepting failure. “You will meet and work with people who have had experiences and exposure to things you haven’t,” Padula said. “It can sometimes feel foreign and disorienting, but if you step back and put yourself in their shoes...you will find that you have more in common than it first appears.”

20

Number of graduate students in the MS in Engineering Design Innovation course Interaction Design who helped design solutions for five undergraduate startups



Creating a Category for Graduate Design Degrees

When most people hear the term “MBA,” they don’t think twice about what it means. The directors of Northwestern’s graduate design programs, however, have found anything but consistency in the world of design degrees. Seventeen years ago, Walter Herbst founded Northwestern’s Master of Product Design and Development Management program, the first of its kind. Now there are 38 similar programs around the world—all bearing different names and offering different coursework.

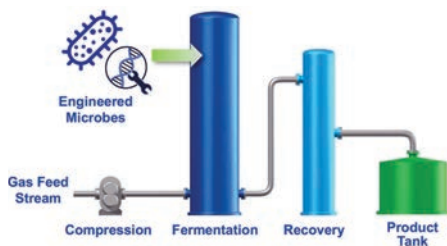
Amy O’Keefe, studio director of Northwestern’s Master of Science in Engineering Design Innovation (EDI) program, recently joined

forces with leaders from five other schools to create the Integrated Design Innovation Consortium. Together, they suggested a unified category name: Integrated Design Innovation. Members of the consortium have collaborated to elevate the awareness of the integrated design innovation degree and envision that it may one day become as well known as the MBA.

Herbst had also embarked on his own extensive study, which became his PhD work. He found that design management programs had 24 differently named degrees. He published a paper on his research and plans to meet with other institutions to discuss standardized coursework and unified branding.

“THERE WERE SO MANY DIFFERENT NAMES FOR JOBS THAT MAKE USE OF THE HUMAN-CENTERED DESIGN PROCESS. ‘CREATING A CATEGORY’ BECAME OUR MANTRA.”

AMY O’KEEFE STUDIO DIRECTOR, MASTER OF SCIENCE IN ENGINEERING DESIGN INNOVATION PROGRAM



NEW CENTER FOR SUSTAINABLE FUEL AND BIOPRODUCT PRODUCTION

Northwestern Engineering will lead a new center dedicated to accelerating the production of sustainable, low-cost biofuels and chemicals. Named the Clostridia Foundry for Biosystems Design, the multi-institutional center has received a five-year, \$12 million grant from the US Department of Energy.

The center’s researchers—from Northwestern, Oak Ridge National Laboratory, and clean-energy startup LanzaTech—will focus on clostridia, a bacterium that metabolizes carbon to produce fuel.

“Clostridia can fix carbon from carbon dioxide and carbon monoxide and use it to grow and make something useful,” says Michael Jewett, the center’s principal investigator. “Essentially, it can turn waste into product.”

A waste-gas-to-fuel startup, LanzaTech houses a collection of clostridia strains. Michael Koepke, who leads LanzaTech’s synthetic biology team, and Jewett have collaborated over the past two years to engineer clostridia to produce sustainable fuels, but engineering microorganisms to perform new tasks is not without its challenges.

Jewett bypasses these challenges by removing the cell from the equation. An expert in cell-free systems, he and his team isolate and activate basic cellular processes outside of the live, intact microorganism. This accelerates testing from a handful of designs in three months to thousands of designs in three days.

“IT’S A REALLY GREEN SOLUTION WITH THE POTENTIAL TO BECOME A MAJOR DRIVER OF GLOBAL INNOVATION AND SUSTAINABLE ECONOMIC GROWTH.”

MICHAEL JEWETT ASSOCIATE PROFESSOR OF CHEMICAL AND BIOLOGICAL ENGINEERING



BITCOIN BASICS

Daniel Polotsky (Weinberg '17) and CoinFlip's Benjamin Weiss visited campus on February 1 to present Intro to Bitcoin and Blockchain, an hour-long, introductory pop-up class that tackled the technology behind Bitcoin and the potential benefits of cryptocurrency in the 21st-century economy.

As the co-founder and CEO of CoinFlip, a Bitcoin ATM service, Polotsky has spent the past three years exploring the potential of cryptocurrency, a new digital asset class that lacks the inflationary tendencies of government-issued fiat money. He founded CoinFlip in 2015 while studying economics and Russian at Northwestern. Today, the company operates 57 walk-up Bitcoin ATM machines.

"Only invest what you would be willing to lose," says Polotsky, who took the Farley Center's ENTREP 395: Growing and Monetizing Your Fanbase course while developing CoinFlip at Northwestern. "We've seen customers invest their life savings into cryptocurrencies. If you over-extend an asset, it clouds your decision making and you end up losing."



\$50,000

Amount won by student startup NUMiX at the Rice Business Plan Competition



1 BILLION

Number of people worldwide who lack access to electricity. Experts discussed how self-contained microgrids could provide electricity in developing areas at Northwestern's Symposium on Microgrids: Renewable Energy Microgrids for Sustainable Development

"With its MMM Program and passion for design thinking, Northwestern is a premiere design and innovation community. We wanted to showcase this to other schools."

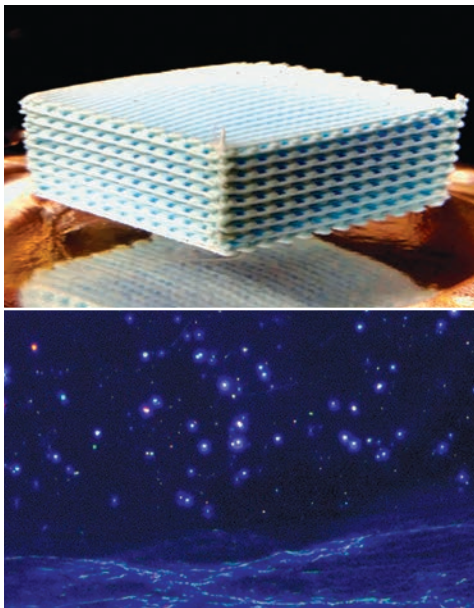
CLAIRE HENDERSON MMM STUDENT



MMM Students Compete in Kellogg Design Challenge

Nearly 200 students from six universities converged on Northwestern on November 11 to compete in the 2017 Kellogg Design Challenge. This year, Procter & Gamble's Pampers team challenged students to rethink childbirth education and find new ways to better deliver information to millennial parents.

For the first time, the long-running competition opened its doors to teams outside of Northwestern. A team from the University of Toronto's Rotman School of Management received first place. IIT's Institute of Design took second, and a team from Northwestern's MMM Program finished in third place. The MMM team developed a solution to give expectant parents the tools to host in-home neonatal health education sessions with their friends and family.



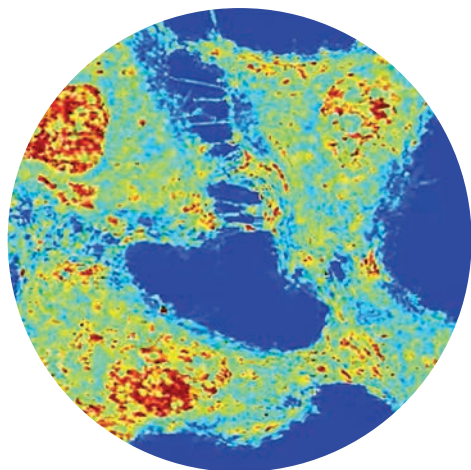
ENGINEERS SHOWCASE SCIENTIFIC BEAUTY

Who knew salt could be so beautiful? Two Northwestern Engineering projects—both featuring salt—took second and fifth places in Science in Society's annual scientific images contest. Northwestern entries also received four honorable mentions.

Dedicated to science education and public engagement, Science in Society unveiled its five winning images and seven honorable mentions on November 2, 2017. A panel of artists, scientists, and community members judged the submissions.

A 3D-printed copper salt structure submitted by postdoctoral fellow Adam Jakus earned second place. When the structure is placed in water, the copper salt dissolves to leave behind a porous, incredibly light, sponge-like material, which can be used to implant gel and liquid biomaterials during surgery.

"Salty Night," submitted by graduate student Nick Sather, took fifth place. The "stars" in Sather's image are salt crystals, which help solidify a hydrogel that can be 3D-printed into any shape for applications such as implants to heal damaged cartilage in human joints.



TARGETING CANCER'S ACHILLES' HEEL

Professor Vadim Backman has developed an effective new strategy for treating cancer, wiping out the disease almost completely in cellular cultures in the laboratory. Backman's approach works by controlling chromatin, a group of macromolecules—including DNA, RNA, and proteins—that houses genetic information within cells and determines which genes get suppressed or expressed.

In the case of cancer, chromatin has the ability to regulate the capacity of cancer cells to find ways to adapt to treatment by expressing genes that allow the cancer cells to become resistant to treatment. Backman's solution alters chromatin's structure in a way that prevents cancer from evolving to withstand treatment, making the disease an easier target for existing drugs. If the cells cannot evolve to resist chemotherapy, for example, they die. After having shown great potential to fight cancer in cellular cultures, the new strategy is now undergoing studies in an animal model.

"COMPLEX DISEASES SUCH AS CANCER DO NOT DEPEND ON THE BEHAVIOR OF INDIVIDUAL GENES, BUT ON THE COMPLEX INTERPLAY AMONG TENS OF THOUSANDS OF GENES. BY TARGETING CHROMATIN, WE CAN MODULATE GLOBAL PATTERNS IN GENE EXPRESSION."

VADIM BACKMAN WALTER DILL SCOTT PROFESSOR OF BIOMEDICAL ENGINEERING



STRETCHABLE ELECTRONICS AID STROKE RECOVERY

A groundbreaking new sensor designed to be worn on the throat could be a game changer in the field of stroke rehabilitation. Developed in the lab of Professor John A. Rogers, in partnership with Shirley Ryan AbilityLab, the sensor is the latest in Rogers's growing portfolio of stretchable electronics.

The new bandage-like throat sensor measures patients' swallowing ability and patterns of speech. The sensors aid in the diagnosis and treatment of aphasia, a communication disorder associated with stroke. Shirley Ryan AbilityLab, a research hospital in Chicago, uses the throat sensor in conjunction with electronic biosensors—also developed in Rogers's lab—on the legs, arms, and chest to monitor stroke patients' recovery progress. The intermodal system of sensors streams data wirelessly to clinicians' phones and computers, providing a quantitative, full-body picture of patients' advanced physical and physiological responses in real time.

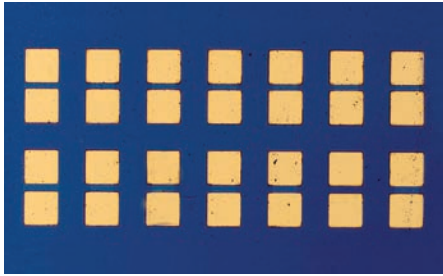
8

Number of students who will participate in this summer's Synthetic Biology Research Experience for Undergraduates



90

Degrees by which Pablo Picasso rotated another painter's canvas before painting over the work, according to Northwestern research



CLOSING IN ON BRAIN-LIKE COMPUTING

Computer algorithms might be performing brain-like functions, such as facial recognition and language translation, but computers themselves have yet to operate like brains. “Computers have separate processing and memory storage units, whereas the brain uses neurons to perform both functions,” says Professor Mark C. Hersam. “Neural networks can achieve complicated computation with significantly lower energy consumption compared to a digital computer.”

In recent years, researchers have searched for ways to make computers more neuro-morphic, or brain-like, in order to perform increasingly complicated tasks with high efficiency. Hersam has developed a novel device called a “memtransistor,” which operates much like a neuron by performing both memory and information processing. With combined characteristics of a memristor and transistor, the memtransistor also encompasses multiple terminals that operate more similarly to a neural network.

17

Number of rare-earth elements studied by Christopher Wolverton to better understand why cerium is the best element to use when splitting water into hydrogen and oxygen



1,500

Number of cell phone users whose motion sensor data Yan Chen used to develop an app that tracks movements to determine whether the owner or someone else is accessing a phone

“The broader goal is to provide a technology platform that can save lives and reduce skin cancers by allowing individuals, on a personalized level, to modulate their exposure to the sun.”

JOHN A. ROGERS LOUIS SIMPSON AND KIMBERLY QUERREY PROFESSOR OF MATERIALS SCIENCE AND ENGINEERING, BIOMEDICAL ENGINEERING AND NEUROLOGICAL SURGERY



WORLD'S SMALLEST WEARABLE MEASURES UV EXPOSURE

In collaboration with the global beauty company L'Oréal, Professor John A. Rogers and his team have developed the smallest wearable device ever. The wafer-thin, feather-light sensor fits on a fingernail and precisely measures a person's exposure to UV light from the sun.

The device, as light as a raindrop and smaller in circumference than an M&M, is powered by the sun and contains the world's most sophisticated and accurate UV dosimeter. Called “UV Sense,” the device has no moving parts and no battery, is waterproof, and can be attached to almost any part of the body or clothing. It is meant to stick on a thumbnail—a stable, rigid surface that ensures robust device adherence.

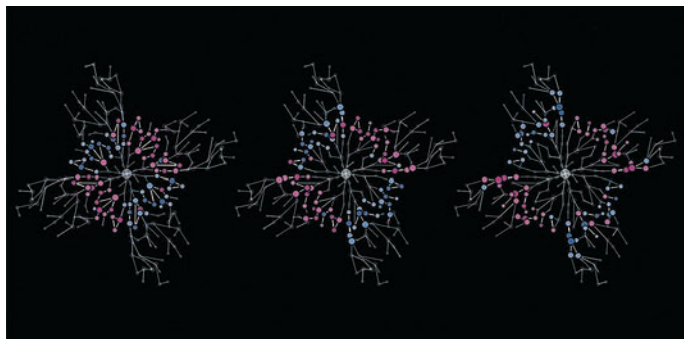


Finding the Origin of Picasso's Bronzes

Musée national Picasso-Paris and the Northwestern University/Art Institute of Chicago Center for Scientific Studies in the Arts have completed the first major material survey and study of the French museum's world-renowned Pablo Picasso bronzes.

The international research team of scientists, art conservators, and curators used portable instruments and a robust database of alloy “fingerprints” to noninvasively analyze a priceless group of 39 bronzes and 11 painted sheet metal sculptures.

The researchers traced five bronzes cast in Paris during World War II to the foundry of Émile Robecchi, a lesser-known collaborator of Picasso. They also discovered Robecchi's alloy compositions varied significantly during 1941 and 1942, likely reflecting the challenging circumstances of the Nazi occupation of Paris. In their study of Picasso's cast-iron sheet metal sculptures, the researchers are the first to report the use of silver for facial features in a work inspired by one of Picasso's wives.



ALGORITHM UNCOVERS INTERACTIONS IN GENE SYSTEMS

Biologists have long understood the various parts within the cell, but how these parts interact with and respond to each other is largely unknown. To better understand these mysterious interactions, Professor Neda Bagheri and her team have designed a new machine-learning algorithm that can help connect the dots among the genes' interactions inside cellular networks. Called "Sliding Window Inference for Network Generation," or SWING, the algorithm uses time-series data to reveal the underlying structure of cellular networks.

"WE WANT TO UNDERSTAND HOW CELLS MAKE DECISIONS SO WE CAN CONTROL THE DECISIONS THEY MAKE. A CELL MIGHT DECIDE TO DIVIDE UNCONTROLLABLY, WHICH IS THE CASE WITH CANCER. IF WE UNDERSTAND HOW CELLS MAKE THAT DECISION, WE CAN DESIGN STRATEGIES TO INTERVENE."

NEDA BAGHERI ASSISTANT PROFESSOR OF CHEMICAL AND BIOLOGICAL ENGINEERING



200

Times faster than previous methods that Chris Wolverton's method can discover and improve metallic glass blends



3

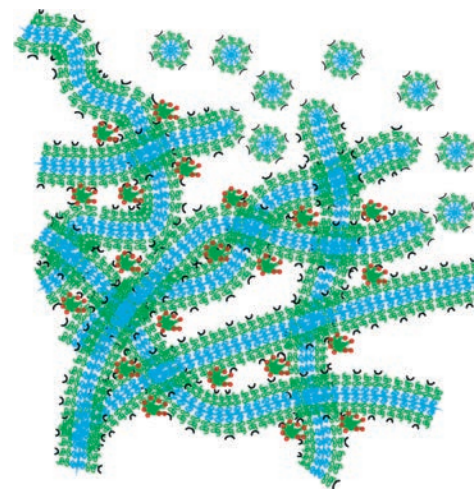
Number of Northwestern faculty members who were elected in April to the American Institute for Medical and Biological Engineering's College of Fellows

INJECTING NANOMATERIALS FOR SUSTAINED DRUG DELIVERY

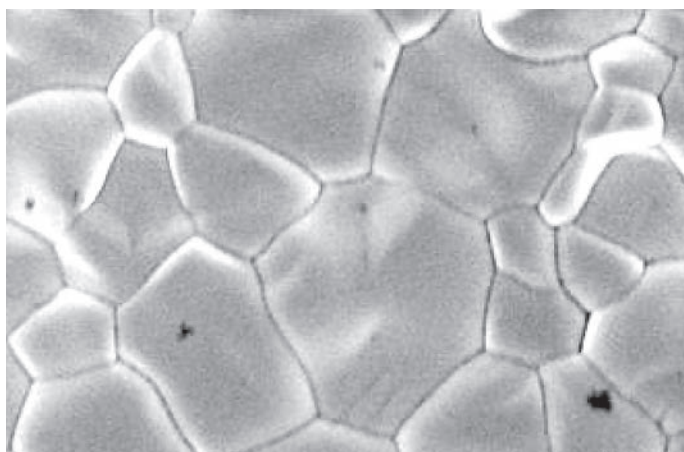
Because they can be programmed to travel the body and selectively target cancer and other sites of disease, nanoscale vehicles called nanocarriers can deliver higher concentrations of drugs to bombard specific areas of the body while minimizing systemic side effects.

Although this method might seem ideal for treating diseases, sustained delivery is difficult to achieve without inducing local inflammation. Instead, nanomaterials are typically administered as multiple separate injections.

Now Professor Evan Scott has designed a nanocarrier formulation that—after quickly forming into a gel inside the body at the site of injection—can continuously release nanoscale drug-loaded vehicles for months without causing inflammation.



New Fuel Cell Has Exceptional Power Density and Stability



A team of researchers led by Professor Sossina Haile has created a new fuel cell that offers both exceptional power densities and long-term stability at optimal temperatures, a discovery that heightens the viability of incorporating fuel cells into a sustainable energy future.

"For years, industry has told us that the holy grail is getting fuel cells to work at 500 degrees Celsius and with high power density, which means a longer life and less expensive components," Haile says. "With this research, we can now envision a path to making cost-effective fuel cells and transforming the energy landscape."

The new fuel cell combines a high-activity cathode with a new electrolyte that allows ions to move quickly. Unlike previous fuel cells, the new cell remained stable even when operated for hundreds of hours.



CRUMPLED GRAPHENE BALLS FOR BETTER BATTERIES

Lithium metal-based batteries, with their theoretically ultra-high capacity, can power everything from personal devices to cars. But as lithium gets charged and discharged in a battery, it starts to grow dendrites and filaments, which leads to rapid degradation of the battery's performance.


Professor Jiaxing Huang and his collaborators have solved this problem by creating a scaffold made from crumpled graphene balls, which can stack with ease to form a porous scaffold because of their paper ball-like shape. Inside the battery, the scaffold not only prevents dendrite growth but can also survive the stress from the fluctuating volume of lithium.



2,600

Versions of a protein tested by Danielle Tullman-Ercek to create a virus shell that could be used in drug delivery

New Lithium-Rich Battery Could Last Much Longer



On paper, it doesn't seem like Professor Christopher Wolverton's super lithium-rich battery should work. For starters, the novel battery uses iron, an inexpensive metal that has notoriously failed in batteries. Adding another challenge, the battery leverages oxygen to help drive the chemical reaction, which researchers had believed would cause the battery to become unstable.

Not only does the battery work, it also does so incredibly well. Teaming up with researchers at Argonne National Laboratory, Wolverton's group developed a rechargeable lithium-iron-oxide battery that can

cycle more lithium ions than its common lithium-cobalt-oxide counterpart. The result is a much higher capacity battery that could enable smart phones and battery-powered automobiles to operate much longer on a single charge.

Lithium-ion batteries work by shuttling lithium ions back and forth between the anode and the cathode. When the battery is charged, the ions move back to the anode, where they are stored. The cathode is made from a compound that comprises lithium ions, a transition metal, and oxygen.

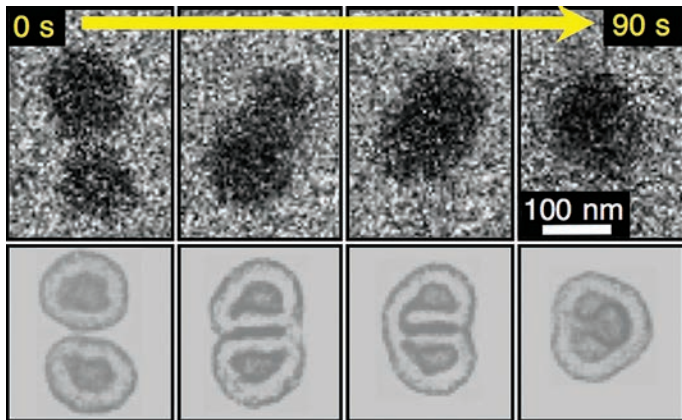
The transition metal, which is typically cobalt, effectively stores and releases electrical energy when lithium ions move from the anode to the cathode and back. The lithium-cobalt-oxide battery has been on the market for 20 years, but researchers have long searched for a less expensive, higher capacity replacement. Wolverton's team has improved on the common lithium-cobalt-oxide battery by leveraging two strategies: replacing cobalt with iron and forcing oxygen to participate in the reaction process.



GRAPHENE FINDS NEW APPLICATION: HAIR DYE

Dyeing your hair too often can damage those silky strands irreparably. Professor Jiaxing Huang and his team have leveraged the super material graphene to develop a new non-damaging hair dye that lasts through many washes without fading. Huang and his team bypassed harmful chemicals altogether by leveraging the natural geometry of graphene sheets.

While currently available hair dyes use a cocktail of small molecules that work by chemically altering the hair, graphene sheets are soft and flexible, so they wrap around each strand of hair for an even coat. Huang's ink formula also incorporates non-toxic polymer binders to ensure that the graphene sticks—and lasts through at least 30 washes. Graphene is anti-static, so it keeps winter-weather flyaways to a minimum, and its conductive nature opens up new opportunities for hair, such as turning it into in situ electrodes or integrating it with wearable electronic devices.



COLLIDING ORGANIC NANOPARTICLES CAPTURED ON VIDEO

A research team led by Professor Nathan C. Gianneschi is the first to capture on video organic nanoparticles colliding and fusing together. In the study, when organic particles in water bounce off each other, some collide and merge, undergoing a physical transformation. Researchers captured the action by shining an electron beam through the sample. This unprecedented view of “chemistry in motion” will aid nanoscientists developing new drug delivery methods and demonstrate to researchers worldwide how an emerging imaging technique opens a new window into a very tiny world.

Creating a Better RNA Switch

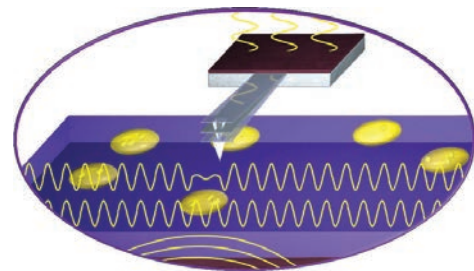
If scientists could precisely regulate gene expression, they could turn off the genes responsible for illness and disease and turn on those that enhance health and the immune system. With that goal in mind, Professor Julius Lucks and his team have developed a powerful and versatile tool that achieves gene activation thousands of times better than nature.

Using a computational design approach, Lucks created the switch by molecularly programming an RNA molecule called small transcription activating RNA. He then used an algorithm to optimize the molecule for specific applications.



5

Height in millimeters of a new 3D-printed lens developed by Cheng Sun



NEW IMAGING TECHNIQUE PEERS INTO LIVING CELLS

To undergo high-resolution imaging, cells often must be sliced and diced, dehydrated, painted with toxic stains, or embedded in resin. For cells, the result is certain death.

Unfortunately, if researchers can only view the inner workings of dead cells, they only see part of the story. They cannot monitor living cells’ dynamic real-time processes, such as metabolic reactions or responses to diseases or treatments.

Research Professor Gajendra Shekhawat and Professor Vinayak P. Dravid have developed a novel, noninvasive imaging system for viewing the sub-cellular architecture of live cells at nanoscale resolution. Called ultrasound bioprobe, the technique combines ultrasound waves with atomic force microscopy, interacting with live cells to determine the changes in their mechanical behavior.

Next, the team plans to expand its technique to diverse biomedical applications, including the nanomechanics of soft tissues such as skin, enamels, and bones to probe their three-dimensional architecture down to nanoscale spatial resolution.



ENTANGLING BIOLOGICAL SYSTEMS

Professor Prem Kumar and his team have, for the first time, created quantum entanglement from a biological system. This finding could advance scientists’ fundamental understanding of biology and open doors to exploit biological tools to enable new functions by harnessing quantum mechanics.

Quantum entanglement is one of quantum mechanics’ most mystifying phenomena. When two particles—such as atoms, photons, or electrons—are entangled, they experience an inexplicable link that is maintained even if the particles are on opposite sides of the universe. While entangled, the particles’ behavior is tied to one another.

In the study, Kumar’s team used green fluorescent proteins, which are responsible for bioluminescence and commonly used in biomedical research. The team successfully demonstrated a type of entanglement called polarization entanglement between photon pairs.

“The reason we are interested in these new quantum states is because they allow applications that are otherwise impossible.”

PREM KUMAR PROFESSOR OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE



Stephen Davis



Teresa K. Woodruff



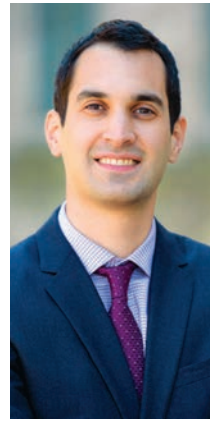
Guillermo Ameer



Walter Herbst



Chad Mirkin



Sinan Keten



Mark C. Hersam



Yonggang Huang



Jorge Nocedal



Ken Forbus



Manijeh Razeghi



Kevin Lynch

Faculty Awards

Stephen Davis Elected into Academia Europaea The international association of scientists and scholars is comparable to the National Academy of Sciences.

Three Named to National Academy of Inventors Walter Herbst, Mark C. Hersam, and Teresa K. Woodruff were named 2018 fellows for demonstrating prolific spirit of innovation in creating or facilitating outstanding inventions.

Ken Forbus Receives Inaugural Herbert A. Simon Prize The award from the Cognitive Systems Foundation recognizes scientists who have made contributions to human and machine intelligence through design, creation, and study of computational artifacts that exhibit high-level cognition.

Two Elected Foreign Members of Chinese Academy of Sciences Chad Mirkin and Yonggang Huang were selected for their scientific achievements and contributions to promoting the development of science and technology in China.

Manijeh Razeghi Receives 2018 Benjamin Franklin Medal in Electrical Engineering The award, for excellence in research, was given by The Franklin Institute, one of the oldest centers for science education and development in the country.

Guillermo Ameer Elected Fellow of AIChE Nominated by their peers, American Institute of Chemical Engineers fellows are elite members who have practiced chemical engineering for more than 25 years and made significant contributions to the profession.

Sinan Keten Awarded Young Investigator Medal The prize, from the Society of Engineering Science, is awarded annually to one or two early career researchers who have already made an impact on their fields.

Narrative Science Receives Chicago Innovation Award Founded by computer science professors Kristian Hammond and Larry Birnbaum, the tech startup was among 25 winners selected from more than 530 nominees.

Jorge Nocedal Presented with John von Neumann Theory Prize The award from the Institute for Operations Research and the Management Sciences is widely regarded as the most prestigious theory prize in operations research.


Joseph Moskal Honored with Top Biotechnology Innovator Award The Illinois Biotechnology Innovation Organization, an industry association dedicated to making Illinois and the Midwest a leader in life sciences ventures and technology, honored him with the iCON Innovator Award.

Kevin Lynch Receives Harashima Award Given by the IEEE/RSJ International Conference on Intelligent Robots and Systems, the award celebrates Lynch's contributions to robotic manipulation.



ART + ENGINEERING

Northwestern Engineering partners with the Block Museum to inspire a new generation of independent thinkers.



NEARLY 2,000 YEARS AGO in the Fayum region of Egypt—an agriculturally rich area west of the Nile Valley—a relatively healthy five-year-old girl died, likely of a bacterial or viral infection.

Though such deaths were common, her well-off family mourned her in what was then the traditional local custom: mummification.

Her organs were removed, but her heart was kept in place. She was embalmed, wrapped in 10 square meters of expensive linen, and given a final parting gift: a portrait painted on a wooden panel and fitted within ornate wrappings around her head.

She was then placed in a tomb, where she lay until 1910. Her journey from there has taken many twists and turns—from London to Chicago, from a seminary to a hospital and a high-energy X-ray facility—that her mourning family could never have imagined so long ago.

But one mystery has always remained unsolved: Who was this girl?

Over the past year, Northwestern students, faculty, and researchers from art, engineering, classics, and medicine have all come together to examine her journey, propose theories, conduct research, and ultimately to exhibit their work, all in the quest of solving the mystery.

CREATING CATALYTIC CONNECTIONS

“If we knew the stories of our lives from the day we were born, why would we live them?”

That question—posed by Lisa Graziose Corrin, the Ellen Philips Katz Director of Northwestern’s Mary and Leigh Block Museum of Art—is perhaps *the* question, meant to jolt young students out of complacency and into a world of risk and uncertainty. After all, life is not about the outcome, it’s about the process, the journey.

That frame of mind, essential to artists, must sometimes be taught to young engineers who can too easily approach a problem as though they could find the answer in the back of the book. It’s also the frame of mind that forms the basis for whole-brain engineering, Northwestern Engineering Dean Julio M. Ottino’s framework for teaching students to combine both analysis and creativity to solve problems that are known and to imagine future possibilities.

Lisa Corrin was unfamiliar with whole-brain engineering when she arrived at Northwestern in 2012. At the time, the Block Museum was shifting its mission to focus more on interdisciplinary teaching and learning based on the idea that art is not just objects hung on walls. One of the first people to connect with her was Ottino. Their shared interdisciplinary mindset proved catalytic.

“He immediately threw down the gauntlet when he said, ‘How should we work together?’” she recalls. Ottino, a painter himself, was eager to find connections to art for engineering students and faculty.

“The value in intersections lies in enriching how the other side thinks,” he says. “At a very basic level, the difference between

art and engineering is indecipherable. Artists and engineers are all creators, but they often take different paths to that point. I wanted those paths to converge, to enrich each other.”

Northwestern Engineering already had several connections with the art world. It’s the home of the Northwestern University/Art Institute of Chicago Center for Scientific Studies in the Arts (NU-ACCESS), which conducts scientific research in conservation and artistic provenance and process. The school also partners in teaching with the Department of Art Theory and Practice in the Weinberg College of Arts and Sciences, and with the School of the Art Institute of Chicago to bring engineering and art students together in the Data as Art course, which challenges groups of students to create art out of datasets.

A partnership with the Block, however, held the potential to add yet another dimension. As Ottino and Corrin brainstormed possible ideas, one thing was clear: they wanted the focus to be not on a project or an outcome, but on the process itself.

To that end, they worked with Susy Bielak, Susan and Stephen Wilson Associate Director of Engagement and curator of public practice at the Block, and Kyle Delaney, executive director of strategic initiatives and marketing at Northwestern Engineering, to invite a carefully selected group of artists—whole-brain thinkers whose work and ideas lie at the intersection of art and science—to deliver a series of lectures and to meet with faculty. “We wanted to see how these artists intersected with our faculty, where potential collaborations might lie, or how they might inspire each other’s thinking,” Ottino says.

HOW TO THINK LIKE AN ARTIST/ENGINEER

At a high level, scientists and artists connect through the need to *make things—to enjoy the process of creation for its own sake.* Julio M. Ottino and Lisa Corrin provide a few tips for those looking to expand their creative and analytical thinking.

Make friends with uncertainty The best ideas come when artists and engineers leave their comfort zones and venture into unknown territory, whether it’s assembling a complex process, designing for a new client, or playing with a new material. “Uncertainty shouldn’t be frightening but exhilarating and energizing,” Corrin says.

Become familiar with the unfamiliar, and vice versa One person might simply enjoy the image of milk gently mixing into coffee, but a physicist might look at the same image and extract the seeds of understanding how regions can remain unmixed in oceans. “This is the essence of science: finding the simple

picture that contains all pictures,” says Ottino, who had this thought himself. Artists do the opposite. “Artists take something cliché and turn it inside out and upside down to get us to see the world anew,” Corrin says. To find the best ideas, do both.

Question, question, question There’s no prize for correctly solving the wrong question, Ottino says. For engineers, getting to a solution means finding the *real* problem, often obscured by the *perceived* problem. It also requires the constraint of operating within physical realities. Artists approach “problems” from a point of nonconformity. As unconventional thinkers unconstrained by the need

for specific, tangible outcomes, they don’t fear being different, a trait that helps them push the boundaries of what’s possible.

Never be satisfied with the first idea

Through Ottino’s whole-brain engineering framework, Northwestern Engineering students iterate, prototype, and communicate until they reach a solution that works, aware there may be others. Artists go even further. “Artists take an idea and play it out beyond its conclusion, sometimes until it collapses,” Corrin says. “They say, ‘Let’s do it to death and see how far this can be pushed and what might emerge.’”

opposite Julio M. Ottino and Lisa Graziose Corrin
Photograph by Sally Ryan





MEANWHILE, BACK AT THE BLOCK

While the team sought out artists for the lecture series, Essi Rönkkö, Block Museum assistant curator, literally and figuratively found herself asking her own set of questions about how a life is lived. In this case, the questions centered on a specific life that had ended quickly almost 2,000 years ago. While preparing for an exhibit at the Block, Rönkkö became an accidental archaeologist: she discovered a mummy.

It wasn't exactly a discovery. The mummy had lain in plain sight in the Garrett-Evangelical Theological Seminary on Northwestern's campus for several years. After its excavation in 1910, the mummy had been displayed in London, then gifted to Lydia Beekman Hibbard of Chicago in recognition of her support of the original excavations. Hibbard in turn gifted it to the Western Theological Seminary in 1912. In 2009, the collections that once belonged to Western were acquired by Garrett-Evangelical, who placed the mummy on display.

Rönkkö's find proved purely serendipitous. She was working with NU-ACCESS co-director Marc Walton to mount an exhibit of mummy portraits from first-century Egypt. Walton, research professor of materials science and engineering, had previously analyzed 15 Roman-Egyptian mummy portraits from the era using advanced imaging techniques to better understand how they were created.

These portraits, housed in the Phoebe A. Hearst Museum of Anthropology at the University of California, Berkeley, had immeasurable historic and artistic value. They represented a shift in artistic thinking: after Egypt became part of the Roman Empire in 30 BCE, Greco-Roman-style, naturalistic two-dimensional portraits on wooden panels were introduced into Egyptian funerary practice. The mummy portraits, painted between 100 and 300 CE, now stand as some of the oldest known portraits in existence; all told, only about 100 mummy portraits remain attached to their wrappings today.

When Rönkkö saw the mummy and noticed it had a portrait intact, she knew that she had found a new dimension for the exhibit. "Having a complete mummy to study transformed our project," she says. "Our first phone call was to conservator Rachel Sabino from the Art Institute of Chicago to determine next steps." Together, they decided to give the mummy a CT scan.

The mummy was carefully transported to Northwestern Memorial Hospital and gently glided into a CT machine for the noninvasive procedure. When mummies were excavated in the 19th century, they were often unrolled at elaborate "unwrapping parties." But modern scanning technology renders unwrapping unnecessary; researchers can peek inside without destroying history.



Photograph by Jim Prisching

According to the mummy's records, an X-ray image of it had been recorded more than 50 years ago to determine that there was a child inside. Rönkkö and the research team had looked at the image, noted a dense object on the abdomen and pins in the wrappings, and wanted to see what else they could find. Stuart Stock ('77, MS '78), research professor of cell and molecular biology at the Feinberg School of Medicine and a Northwestern Engineering alumnus, led the scan.

The results confirmed that the child was five years old when she died, give or take nine months. The portrait depicts a female, but a skeleton cannot confirm gender since skeletal differences emerge in puberty. The mummy's soft tissue is well preserved, though, and the absence of male external genitalia indicates that the child was a girl, according to the team's forensic anthropologist, Michala Stock (WCAS '10). The child's organs except the heart had been removed, and her nasal cavity had been perforated in order to remove the brain. Resin, which was poured into the cranium to help preserve the body, had pooled in the base of the skull.

As happens in most research, the results didn't answer every question: What was that dense sphere above her abdomen? What were the wires around her head and feet?

A FIRST AT ARGONNE

The search for more answers continued when the mummy took yet another trip, this time to Argonne National Laboratory, for the first-ever scan of a mummy there. Researchers used the extremely brilliant high-energy synchrotron X-rays produced by Argonne's Advanced Photon Source to probe the materials and objects inside the mummy.

Stuart Stock and his team shone the pencil-shaped X-ray beam (about twice the diameter of a human hair) on the areas of high-density in the mummy that had been identified in the CT scan. They then used the X-ray diffraction patterns as "fingerprints" to identify the crystalline materials.

That circular-shaped object above her abdomen? It consisted of high purity calcite, a major constituent of a material known as alabaster or travertine in historical documents. The material is soft and easily carved, raising speculation that the object could be a carved scarab amulet, a common burial accompaniment.

Those wires around her head and feet? Turns out they are modern dual phase steel, similar to the material used in specimen pins in entomology. They were added later, likely to keep the wrappings in place.

KEY SCAN FINDINGS

Five-year-old child

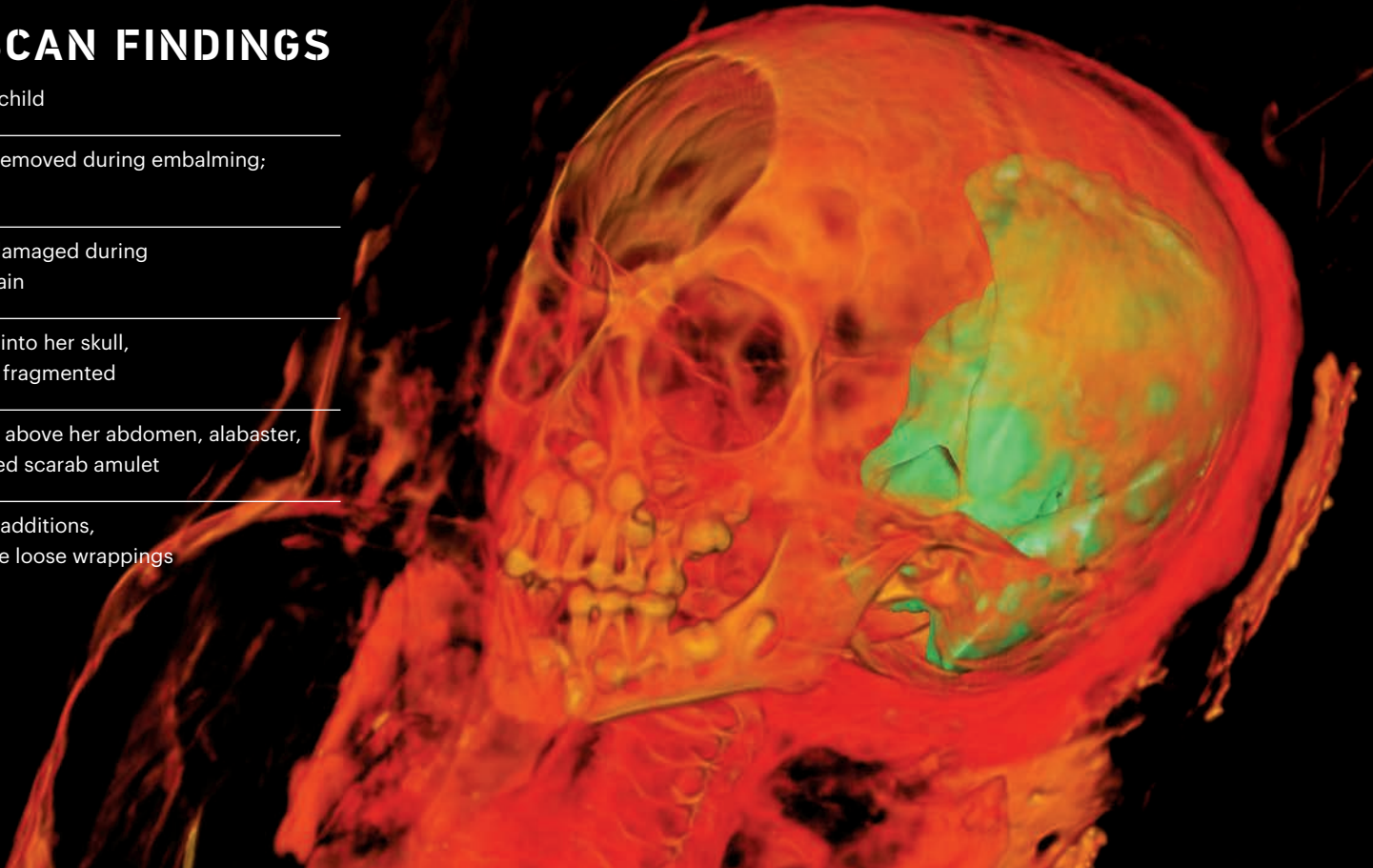
Most organs removed during embalming;
heart intact

Nasal cavity damaged during
removal of brain

Resin poured into her skull,
solidified and fragmented

Dense sphere above her abdomen,
possibly carved scarab amulet

Pins, modern additions,
used to secure loose wrappings



AN INSIDE VIEW

Visitors to the exhibit had an opportunity to see the internal structure of the mummy using a hands-on digital window. This interactive visualization was developed by electrical engineering and computer science senior Kyle Engelmann, mentored by Professor Oliver Cossairt and PhD candidate Nathan Matsuda. Engelmann converted the segmented CT data to a polygon surface representation suitable for real-time display, then developed a rendering model emulating X-ray images, which, when combined with Apple's visual and inertial odometry tools, gave visitors a unique perspective.

Images courtesy of Block Museum of Art



Stock is still analyzing the mummy's tooth enamel and cortical bones. "From a medical research perspective, I am interested in what we can learn about her bone tissue," he says.

To further study the mummy, Walton led a course, which included engineering and humanities students, during fall semester 2017. Co-taught by Taco Terpstra, assistant professor of classics and history at Northwestern, the course challenged students to use research techniques in materials science, archaeology, and museum studies to understand how these ancient materials were created and used.

Students used a technique called X-ray fluorescence to determine the distribution of iron, lead, and copper in the girl's mummy portrait, which suggested significant use of ochres, Egyptian blues, and lead white paint. They also used computational imaging to determine that the paint was textured and thick, typical of encaustic painting (pigment mixed with beeswax) associated with mummy portraits from the Fayum region.

"This was a once-in-a-lifetime opportunity for our undergraduate students—and for me—to work at understanding the whole object," Walton says. "Today's powerful analytical tools allow us to nondestructively do the archaeology scientists couldn't do 100 years ago."

The team's findings were on display at the Block's exhibit, "Paint the Eyes Softer: Mummy Portraits from Roman Egypt," which ran through April 2018.

ARTISTS AT THE INTERSECTION

Through the art/engineering collaboration, five interdisciplinary artists visited Northwestern in 2016 and 2017, lecturing on their work at both Northwestern Engineering and the Block. They also spent several days meeting with faculty and students "to see what intersections might exist," Bielak says. "We created a framework for immersive site visits considering each artist's past, present, and future research," she says. "Artists met with faculty across disciplines in areas such as robotics, computer science, synthetic biology, and nanotechnology, along with bioethics, poetry, and art history."

In these conversations, artists and engineers shared their research methods, questions, and moments of revelation. For example, Professor Yonggang Huang shared how kirigami, the Japanese paper art of folding and cutting, inspired a new 3D fabrication method. Artists and engineers also found common ground in philosophical questions, such as the ethics of synthetic biology and artificial intelligence. "It became clear that there could be infinite projects borne out of a dozen conversations in a visit," Bielak says. "Working hand-in-glove together across units enabled us to see the potential for future and deeper collaboration. While we intentionally kept the artist visits open without a concrete goal in mind, they have already resulted in two longer residencies."

Jen Bervin, an artist and poet whose research-driven works weave together art, writing, and science, was inspired by a meeting with professor Huang and by his work on stretchable, flexible electronics.

Bervin had previously worked with bioengineers to create a nanoscale poem in the form of a silk biosensor. When she returned to Northwestern in winter 2018 as the Kaplan Artist in Residence, she taught a studio course in advanced materials that looked to Huang's work and that of other faculty working across fields from materials science to nanotechnology as inspiration for researching materials as a source of content and form.

Dario Robleto, a visiting artist whose work ranges from sculptures to soundscapes, returned in May 2018 for a month-long residency as an artist-at-large. His work often straddles the boundaries of art and science; he previously worked with a sound archaeologist to find a way to turn 19th century heartbeat tracings into playable sounds.

"Dario has tremendous experience working collaboratively with members of a scientific community. The very nature of what he does—his practice is rooted in research—demonstrates his interest in interdisciplinary thinking," Corrin says.

Ottino says faculty members were impressed with Robleto's work and his interest in being involved in the research process. As part of his residency, Robleto planned to meet with synthetic biology faculty members to discuss ethics and to work with computer science faculty members and the Segal Design Institute to help students move from a web of inspiration to a concrete idea. "The hope was that by giving Dario a 'hall pass,' by giving him access to the incredible brain trust of McCormick, and by putting him in direct contact with people whose work could be catalytic for him, we would enable relationships to evolve and connections to happen organically," Bielak says.

UNSEEN HORIZONS

After the close of the exhibit, the mummy returned to the library, freshly cleaned with a new case and newly installed climate control measures to "keep her in a more stable environment," Rönkkö says. Though the girl's story was partially illuminated, faculty and researchers can only imagine what future technology might reveal. That sort of speculation fuels the future of the art/engineering partnership. Both sides plan to regroup after Robleto's residency to see what worked, what didn't, and what they might plan for the future.

"We don't know where it's going to lead, and that's okay," Corrin says. "I hope this process is a model for students—that great discoveries come from an organic process, not one that is foreclosed from the outset."

So far, both sides see the partnership as a success because it changed the imaginative landscapes of both faculty and students. "Why can't an outcome be a change in the way students think?" Corrin says. "What if this does nothing more than give a scientist courage? Then that's a success. At the end of the day, it's not about residencies, lectures, and exhibitions. It's about a way to be in the world as an individual."

EMILY AYSHFORD

WITH CONTRIBUTIONS BY MEGAN FELLMAN



DOLLARS AND DESIGN SENSE

Students in Northwestern's MMM Program combine design thinking and business expertise in a collaborative initiative with Visa.



When Visa's Shiv Singh wanted to explore how to help banks and merchants better interact with their customers, he had no shortage of resources to help him.

As Visa's senior vice president of innovation and strategic partnerships, Singh had access to an expansive team of designers and creative minds working in Visa's nine innovation centers around the world. He also could leverage a network of global startup companies thanks to Visa's Everywhere Initiative, a program that tasks startups to help solve the payment and commerce challenges of tomorrow.

Ultimately, Singh turned not to another group of designers nor the leaders of a technology startup, but rather to a team of students in Northwestern's MMM Program: Mark Sullivan, Adam Attas, Rene Peters, and Zachary Richner.

"At Visa, we believe our future is driven by non-traditional partnerships," Singh says. "We thought if we took the same approach with an interdisciplinary academic program like MMM as we do with the startup community, we could gain a different perspective on the business challenges our customers face."

INTEGRATING DESIGN WITH BUSINESS, ACADEMIA WITH INDUSTRY

The MMM Program is an immersive dual-degree graduate program that integrates business education with design innovation. MMM graduates receive an MS in Design Innovation from Northwestern Engineering and an MBA from Northwestern's Kellogg School of Management.

"The MMM Program empowers future business leaders to innovate using creative and critical thinking skills," says Greg Holderfield, co-director of the MMM Program and director of Northwestern Engineering's Segal Design Institute. "Graduates are uniquely positioned to use design thinking to identify the right problems and lead organizations to solve them well. That combination of skills enables lasting innovation and impact."

For MMM students, the Business Innovation Lab course is the program's capstone educational experience, an opportunity to apply the design innovation and business management lessons learned in the classroom to actual business problems in collaboration with a leading global organization, like Visa.

"The Business Innovation Lab is one of the reasons why I chose the MMM Program," Sullivan says. "To work with a client like Visa is very unique. You might find an opportunity like this some other place, but you'd have to look hard for it. Here, working with a company like Visa is built into the program."

“The human-centered design process focuses on gaining insights from one-on-one interactions. Companies often make a product just because they can. Human-centered design makes sure you address a genuine human need. The in-person feedback often reveals the real problem.”

RENE PETERS



PIVOTING TOWARD HUMAN-CENTERED DESIGN

Interested in leveraging emerging technologies in the finance sector, Visa originally tasked the team to explore how biometrics—retina scans, fingerprints, facial and voice recognition—could improve banking experiences for customers. As the team members began their research, however, they shifted their focus to how couples manage financial decisions together.

Why pivot? The team credits the human-centered design process, one of the MMM Program’s guiding principles that inform design thinking.

“The human-centered design process focuses on gaining insights from one-on-one interactions,” Peters explains. “Companies often make a product just because they can. Human-centered design makes sure you address a genuine human need. The in-person feedback often reveals the real problem.”

The team spent six weeks conducting more than 40 in-person interviews, leveraging their own extended network, placing an ad on Craigslist, and working with professional recruitment agencies to find candidates. When asked about their attitudes toward finances, respondents consistently mentioned the difficult transition that occurs when a couple joins its finances and begins making financial decisions together.

“They not only must reassess their own view of finances, but they also often have interactions with each other that present challenges,” Sullivan says. “That shaped our focus.”

The team’s anecdotal research revealed how emotions drive major financial decisions made by couples. Planning a wedding, for example, requires both partners to align their expectations of how to allocate their combined financial resources to different expenses from venues to caterers to photographers. What’s more, they must also manage input from family members on how to assign and divide costs. With individual values reflected in such financial decisions, reaching consensus can be difficult.

“There’s more to it than just shelling out cash to pay for something,” Sullivan says. “Money is a very emotional issue, especially for people who feel their backs are against the wall.”

Hearing the first-hand stories made the team wonder how it might make these challenging conversations less stressful. Singh welcomed the new direction.

“When the team presented this shift in focus, we loved it,” Singh says. “It demonstrated an interesting evolution in their approach, becoming more human-centered than technology-centered. They discovered an untapped need we were excited to explore.”

GUIDED BY INDUSTRY PROFESSIONALS

Counselling the team throughout the research phase was adviser Michael Chapman, adjunct lecturer in the MMM Program and senior design lead at global design consultancy firm IDEO. Team members met with him weekly at his office in downtown Chicago, beginning each meeting with a recap of the progress made over the previous week. They then prepared for the week ahead—brainstorming, diagramming ideas on a whiteboard, and talking through anticipated challenges. Chapman described the setting as a “living classroom.”

“I had expectations of what the students wanted to work on and had questions to guide the conversation, but our working sessions were often reactive,” Chapman says. “The environment was not at all like a static lecture. It was more like an actual design consultancy.”

“To pick Michael’s brain for two hours every week was incredible,” Richner says. “He advised the team without micromanaging us. He had a way of prodding us in an almost Socratic way, offering help but letting us do the work and get our feet underneath us.”



“Visa has been a great advocate for us. With a whole team of people practicing design thinking, they bought in to our work throughout our collaboration. It’s great to know that our ideas have the potential to be put into practice.”

ZACHARY RICHNER

PROTOTYPES TO GET THE BALL ROLLING

After presenting its initial research findings to Visa, the team embarked on a three-week sprint to design and test potential concepts that could inspire future Visa initiatives. One concept gamified the process of jump-starting financial discussions among couples.

In the game, couples would roll a paper die with one adjective written on each side expressing different emotions, such as “content,” “thrilled,” or “sad.” If the die came up “anxious,” for example, the two would discuss a purchase or payment they felt anxious about in the coming month, six months, and year.

“Couples quickly learned whether they were on the same page or not,” Sullivan says. “Couples often don’t have these conversations at all, or if they do, they’re incomplete. The game showed how an external stimulus can be valuable to spark discussion.”

Another concept simulated the unexpected twists and turns couples encounter as they work toward financial goals. In the exercise, couples would follow their movement across three tracks on a poster board, each leading to a different financial goal, like buying a house or saving for a vacation. The team would present scenarios that impacted movement along each track. A promotion at work allowed couples to move up three spots. A sudden loss of money forced a retreat backward two spots. The exercise tested couples’ ability to prioritize and agree on when to move closer—or farther away—from their goals.

“When people were introduced to a financial setback in the simulation, they really empathized with the situation,” Attas says. “It felt real to them.”

In addition to developing concepts that felt personal to the users testing them, the team designed the prototypes to be adaptable to different modalities, such as physical products or mobile app-based games, and scalable for a large company, like Visa.

“We designed our concepts to promote interaction, to bring out the pleasure of seeing you and your partner aligned on financial decisions or to recognize the need to have more conversations,” Peters says. “To that end, we felt we validated the prototypes and verified that they met a need. There’s a foundation here for Visa to use its resources to build upon the principles these prototypes represent and develop market solutions.”

LASTING IMPACT

In March 2018, the team traveled to Visa’s San Francisco offices to present its concepts and final recommendations to the company’s core innovation team, which included Singh and several of the company’s in-house design thinkers.

While the meeting marked the end of the MMM team’s work on the project, Visa’s work is just beginning. The company plans to use the team’s prototypes and insights gained from its field research to further explore and develop new innovations that will help couples manage turbulent financial situations.

“Visa has been a great advocate for us,” Richner says. “With a whole team of people practicing design thinking, they bought in to our work throughout our collaboration. It’s great to know that our ideas have the potential to be put into practice.”

Looking back at a whirlwind 10 weeks, Attas admits to a newfound appreciation for the role of design in what he previously thought was an analytical field. “I entered this project hoping to use design to demystify some of the complexities in the finance industry,” Attas says. “I quickly learned how important human-centered design is to this field. When you have conversations with people, you experience life through their eyes, and you understand how things like a 401(k) or a joint bank account can bring tension or happiness. To improve lives using design shows how powerful a tool it can be.”

ALEX GERAGE

Gates / Portes

→ ✈️ 101-157

← ✈️ 168-181, 500-550



Wheels Up

NORTHWESTERN STUDENTS WORK
TO TAKE THE STRESS OUT OF AIR TRAVEL
FOR WHEELCHAIR USERS.

When Jessica Lindsay and her family flew to London in 2017, her best friend, Northwestern Engineering graduate student Julia Savich, asked if she could come along—all in the name of research.

“Traveling can be very stressful for anybody,” Lindsay says. “There are the normal things like making sure you pack everything and all that. Our family has even more stress.” Lindsay and her twin sister Jordan both have cerebral palsy and use wheelchairs, which makes traveling especially tricky.

“We always worry: Will the airline lose our chairs?” she says. “Will they take them apart to fit into the cargo hold? What if they break them?”

These are exactly the types of concerns and challenges that Julia Savich and her fellow Northwestern Engineering students are trying to solve in partnership with Chicago’s world-renowned Shirley Ryan AbilityLab, which has been ranked number one in rehabilitation by *U.S. News & World Report* for 27 consecutive years.

For more than two decades, Northwestern Engineering students have worked with the research hospital on solutions for people living with disabilities. Although Northwestern and Shirley Ryan AbilityLab, previously known as the Rehabilitation Institute of Chicago, are separate entities, the two often share resources and work toward common goals—including solving issues using human-centered design.

“The Shirley Ryan AbilityLab is an innovation hub. They’re really striving to do what’s not been done before—seeking new ways to help people with disabilities or the newly injured live better lives,” says Bruce Ankenman, co-director of Northwestern’s Segal Design Institute. “That fits with Northwestern Engineering’s goals.”

USING HUMAN-CENTERED DESIGN FOR GOOD

Exposure to human-centered design begins early in a Northwestern engineering student’s academic career. Every first-year student takes two quarters of Design Thinking and Communication through the Segal Design Institute. There they have opportunities to work with people with disabilities through the hospital.

“Every one of those 500 students will work on a real project for a real person with a disability. It’s life changing for the students,” Ankenman says. “The hospital has about 50 therapists who work with us each year. It’s an army of people.”

In their projects, the students first learn to listen to individuals from the disability community about the challenges they face in their lives; they then design, prototype, and iterate solutions. Past projects have ranged from a tool that enables a stroke victim to button a shirt with one hand to ways to make gardening easier for an arthritis sufferer.

“The students might not always find a solution,” Ankenman says, “but they need to learn, listen, and have empathy.”

Projects with the Shirley Ryan AbilityLab are so popular that students often work on individual design projects in upper-level courses or take on projects through Northwestern’s Design for America, a student initiative that creates local and social impact through interdisciplinary design.

“Many Northwestern students also come back as volunteers and interns as juniors or seniors,” Ankenman says. In increasing numbers, master’s program students like Savich are getting involved as well.

OLD FRIENDS, NEW INSIGHTS

When Julia Savich entered the Master of Science in Engineering Design Innovation (EDI) program, she wanted to design a solution that would help her friend Jessica feel more included and less constrained by using a wheelchair. The two had first met during their first year at Palatine High School, about 30 miles outside of Chicago. Jessica is ambulatory but uses a manual wheelchair for long distances. Her twin sister Jordan uses a custom-built manual chair full time.

“I didn’t really think about how Jessica’s life was different then,” says Savich, who earned her bachelor’s degree in physics from Illinois Wesleyan University in 2016. “I just liked hanging out with her.”

In fall of 2016, Ankenman reached out to the new EDI master’s candidates with a potential project. The Shirley Ryan AbilityLab wanted help to make air travel more accessible for people with wheelchairs.



Photograph by Justin Barbin

“I looked at the whole process of air travel—from getting out of a taxi to sitting on the plane to landing at a destination—to figure out the issues. I talked with people who use power wheelchairs and manual ones.”

JULIA SAVICH

NORTHWESTERN ENGINEERING GRADUATE STUDENT

“It is a big issue when someone’s wheelchair is lost. It is not like they’ve lost their luggage,” Ankenman says. “It’s like they’ve lost their legs.” With her friend in mind, Savich jumped at the opportunity and started researching potential projects that could become her thesis.

AN IDEA TAKES WING

“I looked at the whole process of air travel—from getting out of a taxi to sitting on the plane to landing at a destination—to figure out the issues. I talked with people who use power wheelchairs and manual ones,” Savich says.

Instrumental in Savich’s work was Jessica Pedersen, a research associate professor and occupational therapist at the Shirley Ryan AbilityLab who served as a mentor and facilitated much of Savich’s research. Pedersen’s specialty is evaluating which type of wheelchair would best serve an individual’s needs. She also conducts research on wheelchair use and travel. For about nine months, the two met every other week and emailed regularly.

“Jessica Pedersen had about 30 models of electric wheelchairs for Julia to check out,” Ankenman says. “That’s not the kind of access you typically can get as a graduate student. That let Julia consider every angle of the problem.”

Pedersen introduced Savich to several people who use wheelchairs so she could learn about their travel experiences. On one occasion, the two women learned that the man they were to meet had been admitted to Northwestern Memorial Hospital down the street. “Julia went to the hospital and spent a couple hours with him, talking about his needs,” Pedersen says.

“She’s very mature and has a wonderful way of working with people with disabilities.”

Savich’s research also included talking with the Lindsay family. “Julia came over and interviewed my mom and me about what traveling is like for us, what works and what doesn’t,” Jessica Lindsay says. “We told her about our experiences with broken and lost wheelchairs.” The family suggested Savich fly with them on an upcoming trip to London to see their challenges for herself.

The trip was eye opening. “I had never considered how hard it would be to navigate an airport or even use the bathroom if you’re paralyzed from the waist down,” Savich says. “I’d never thought about how once you’re on the airplane, you’re not able to get out of your seat at all.”

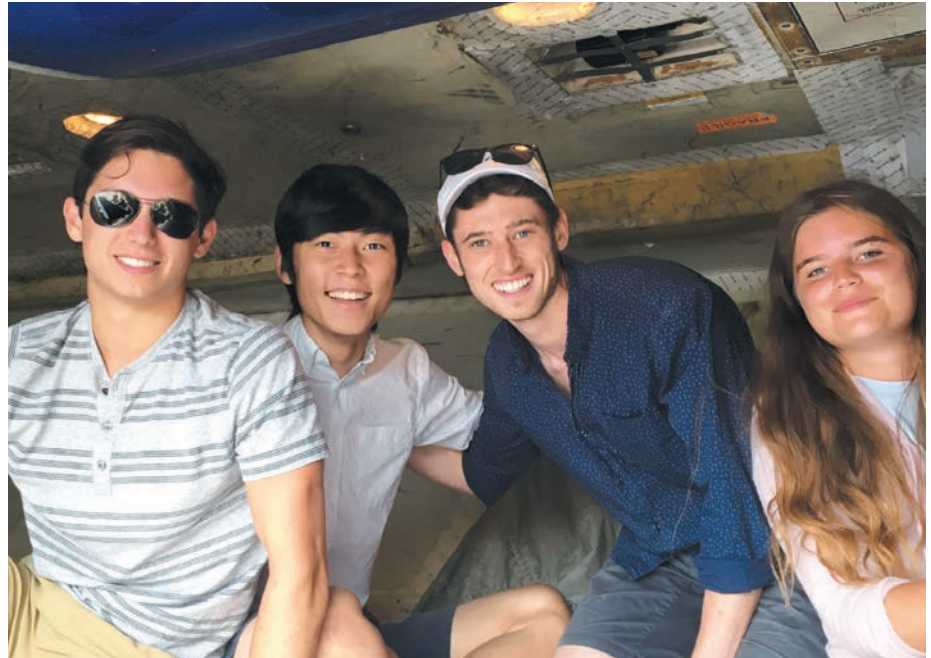
FRAMING THE PROBLEM

Pedersen also helped Savich look at the issue from another point of view—that of the airline baggage handlers. Savich attended two training sessions held on a tarmac in Seattle to teach baggage handlers how to load wheelchairs.

“The Shirley Ryan AbilityLab, with its partner Open Doors Organization, got Julia that access,” Ankenman says. “When they call, the red carpet rolls out.”

Savich learned that motorized chairs, which are highly personalized and very expensive, could easily be damaged by airline baggage handlers. “Wheelchairs are users’ ‘bodies,’ and a damaged chair disrupts their lives beyond the airport,” she says.

Savich also traveled with Pedersen to Washington, D.C., for a meeting of the Rehabilitation Engineering and Assistive Technology Society of North America. There she gathered more new ideas from leading researchers on assistive technology for air travel.



“Jessica Pedersen was incredibly helpful to me. She knew all the stakeholders,” Savich says. “Northwestern’s proximity to the Shirley Ryan AbilityLab is amazing. I couldn’t have had this experience anywhere else.”

Savich leveraged her extensive research to create Paladin, a hollow steel frame to help baggage handlers safely store power wheelchairs. The lightweight frame attaches to the side of the wheelchair before it goes in the cargo hold, preventing baggage handlers from grabbing parts that tend to break and ensuring the chair is stored safely.

STICKING TO IT

While working on her thesis, Savich heard that the work being done by a team of undergraduates in Northwestern’s intensive Design for America Summer Studio program dovetailed with hers. The team—Alex Bloom, Maxwell Leef, Sara Gnolek, and Jintae Park—had developed stickers to be placed on wheelchairs during travel. The colorful stickers can be applied to any type of wheelchair to provide baggage handlers with important information, such as safe lifting points, fragile parts, and how to unlock wheels.

Bloom, a senior majoring in integrated engineering, says, “We met with Julia a couple of times to share resources and see how she was approaching the issue. It was great to exchange notes.”

“The stickers are a good way to raise awareness and hopefully minimize damage,” Savich says. “Having a standard communication method across wheelchair brands and power types means baggage handlers only have to learn one new handling technique, not one for each style of chair.”

The undergraduate group’s enthusiasm continued beyond the summer program, so Savich invited them to Northwestern’s 24-hour Integrated Design Innovation Challenge, hosted by the Shirley Ryan AbilityLab. “This project helped me confirm what I want to do for a career—design for social good,” says Bloom. His team hopes to market the stickers through their website.

HELPING A COMMUNITY

Northwestern students’ projects like the stickers and the wheelchair travel frame can make a tremendous difference in people’s lives, Pedersen says. “It’s a first step in the students’ careers, and it tells members of the disability community that their voices are being heard and there are people looking to make their lives better. It’s powerful.”

Since completing her degree, Savich has worked at Milwaukee Tool as a design researcher. She hopes to continue to refine her Paladin frame and wants to stay active in design for the disability community. “If you’re looking to really make an impact on someone’s life, working with people with disabilities is a great way to do it,” she says. “It’s all up front and personal, trying to create solutions, putting them in the hands of users, and seeing the joy on their faces.”

Savich’s friendship with the Lindsay family continues. “It’s great that Julia’s trying to make a difference for people like us,” Jessica Lindsay says. “She’s very smart, caring, and kind, and she puts others before herself. I feel honored that she had me in mind when she started this project.”

JULIANNE HILL

The background features a complex geometric pattern. It includes a large red circle with a white center at the top left, and another large white circle with a red center at the bottom left. A thick red horizontal bar is positioned below the bottom-left circle. Black lines form a grid-like structure with several circular nodes. The color palette consists of various shades of blue, red, white, and black.

FROM SUBMISSIVE SIDEKICK TO POWERFUL PARTNER

How artificial intelligence can power true collaboration
between humans and machines

Alexa and Siri, move over. Virtual collaborators are coming.

It's a longstanding promise that's finally within reach: the transformation of artificial intelligence (AI) from a tool we use for routine tasks to a constant companion and tireless co-worker that complements our strengths and compensates for our weaknesses.

"We're on the cusp of a shift in how people interact with computers," says Ken Forbus, the Walter P. Murphy Professor of Computer Science at Northwestern Engineering. "Alexa and Siri are relatively simplistic and crude compared to what's to come."

In the not-too-distant future, Forbus predicts, computers using sufficiently smart "software social organisms" will gain intimate knowledge of the humans they encounter, anticipate their needs, and find flaws in their reasoning. Those general yet complex capabilities will enable the human and the machine to become true collaborators—bouncing ideas off one another and playing off each other's strengths.

"Having AI that complements us as human beings, and can even collaborate with us, will make everything work better," Forbus says. "While the sheer complexity of the problems we face is constantly increasing, as a species we're not becoming more complex. The human mind and our cognitive capacity have reached their limits."

SOFTWARE AS SOCIAL ORGANISM

Though this quantum leap for AI remains years away, researchers have begun to create "software social organisms" that can learn a vast range of knowledge and have the capacity to reason. "Social" refers to the software communicating with humans naturally and effectively. "Organisms" refers to the software being self-sufficient.

"Instead of humans learning to code using the language of the computer, the machines will know how to speak with us using language and images," Forbus says. "They will come to us."

"Today, all machine learning involves humans in the process," he continues, "but soon that will go away. In these new systems, there will be no human fiddling behind the scenes, which is what we have with Google and other leading-edge companies now. The machine will set its own learning goals and priorities for self-improvement."

TAKE HEART, ALEXA

"The current intelligent personal assistants, like Alexa, are really kind of cool and at the same time really kind of sad," he says. "They can help with little tasks, but they don't get to know you or your preferences over time. They can't put things in context. They can't answer complex questions using multiple data sets."

Forbus says that will change as AI continues to advance exponentially. Just as apprentices start working as assistants to their mentors and move incrementally toward autonomy, software social organisms will learn from their mentors, growing to the point of engaging in true dialogue, posing robust follow-up questions, and making complex connections.

"These organisms will not be sycophants," Forbus says. "They'll not only collaborate, they can also serve as devil's advocates, looking at the other side of an issue to help point out flaws in our arguments and reasoning while pushing our work to higher levels."

IMPACT ON PEDAGOGY

This coming shift—which essentially removes humans from the process of regulating machines—already has implications for pedagogy. "Today's students are being taught how to run machine-learning software, but that's not a long-term skill. We're not going to have data scientists in the long term," he says.

Anticipating that shift, Northwestern Engineering's new Master of Science in Artificial Intelligence program will expose students to the research and technology that develops virtual collaborators. Forbus's lab has developed one model for teaching computers to reason like humans and even to make moral decisions, and another for equipping them to perform at human levels on standardized tests.

"While everyone else is focused on creating AI tools," he says, "we're talking about something entirely different. Software social organisms would have agency with unlimited opportunities to help students. There are never enough humans in education. Imagine if you had a one-on-one system that helped motivate you and tutor you on your specific needs. That would be amazing."

How much research, engineering, and evaluation are needed to make these collaborators a reality remains unknown, but progress has been made. For example, Narrative Science, an AI company developed by Northwestern computer science professors Kris Hammond and Larry Birnbaum, interprets data and turns it into English-language stories written for specific audiences.

Ultimately, Forbus says, software social organisms will fit into the culture where they reside and become full-fledged partners, making our increasingly complex work more productive and efficient.

JULIANNE HILL

MORE THAN A JOB. LEADERSHIP AND GROWTH.

Northwestern Engineering's director of career development sees great opportunity and competitive advantage for grads' professional success.



When Northwestern Engineering students look to gain experience and secure their futures in the professional world, many turn to **Helen Oloroso** and her team at the McCormick School of Engineering's Office of Career Development.

There, experienced career development professionals work hand-in-hand with students at every level—from undergraduates seeking internships to PhDs eager to work in research labs—to find the right fit to complement their academic pursuits and professional goals. Each year, Oloroso's office works with an average of 1,200 undergraduates, 750 graduate students, and approximately 120 employers.

Oloroso, who has spent more than a quarter-century connecting engineering students and alumni with employers, the last 17 years with Northwestern, has a unique vantage point from which to observe the engineering world's ebbs and flows. Recently, she fielded a few questions about the trends she sees in the engineering professional landscape and the distinct skills Northwestern Engineering students and alumni bring to the marketplace.

WHAT SPECIAL SKILLS DO NORTHWESTERN STUDENTS IN PARTICULAR BRING TO THE PROFESSIONAL ENVIRONMENT?

Even though engineers historically have been given a bad rap for their communication skills, employers tell us loud and clear that they prize Northwestern students' communication abilities. They also tell us that our students demonstrate exceptional capabilities for problem-solving.

I've heard the expression "blew the doors off" more than a few times from employers. I attribute this reaction to Northwestern Engineering's emphasis on whole-brain engineering and the design-thinking and communication framework we deploy across our curriculum. Our students and alumni are ready to join a team, identify problems, and craft intelligent and elegant solutions.

WHAT BIG CHANGES HAVE YOU WITNESSED IN ENGINEERING AND BUSINESS OVER THE SPAN OF YOUR CAREER?

Today, there's certainly a greater emphasis on entrepreneurship as the economy's ability to support and nurture startups has changed dramatically. There's more opportunity to create value in tangible or intangible ways, and that just wasn't the case a few short years ago.

When we endured the dot-com boom and bust in the late 1990s, we hadn't found a way to monetize the web and encourage startups like we're doing today. Perhaps that hard fall then was necessary to create the robust startup environment we enjoy now.

The other big change is globalization. That has a lot to do with supply chains, of course, but also the way in which the web supports borderless commerce and enterprises.

HOW DO YOU SEE THE ENGINEERING CAREER MARKETPLACE EVOLVING IN THE YEARS AHEAD?

As bots become more ubiquitous in every profession, in every occupation, I'm hearing more and more about "STEMpathy," the mix of STEM knowledge with empathy. Tools don't fill every need, and people with social science and human interaction skills can connect the dots and bring it all together. Those able to employ "STEMpathy" are in a real position to thrive.

FROM AN EMPLOYER'S PERSPECTIVE, WHAT SPECIFIC SKILLS AND EXPERIENCES ARE MOST IN DEMAND?

Computer programming skills—the ability to customize, write, or deploy proprietary applications—remain in high demand, though analytics is closing in as businesses increasingly use big data to optimize what they're doing. There's also a growing focus on the soft skills. Employers want to see demonstrated ability to collaborate with others and flexibility to adapt to changing circumstances.

SPEAKING OF OPPORTUNITIES, ARE YOU SEEING ENGINEERING GRADUATES MOVING INTO NON-ENGINEERING ROLES?

Absolutely. With the increasing emphasis on big data and rapid advancements in artificial intelligence, many employers see that engineers possess the requisite skills to turn data into practical knowledge. An employer might hire one of our graduates to fill an engineering position fully aware that it could be just the first step on that individual's path to leadership or an expanded role within the company.

NORTHWESTERN ENGINEERING STUDENTS AND ALUMNI TAKE SO MANY DIFFERENT PROFESSIONAL PATHWAYS. WHY IS THAT?

A lot has to do with the students we're recruiting in the first place. The output is really an enhancement of the input. We don't take blank slates and create multidimensional individuals with varied interests and ambitions. Rather, our students come to us that way, and we provide an environment in which they can flourish and refine their capabilities. We don't focus on the analytic to the exclusion of the aesthetic or the creative. That means our students and alumni see more opportunities and ways to express their talents and deploy their education.



REGENERATION REVOLUTION

Guillermo Ameer positions Northwestern for leadership in regenerative engineering.

“I’m excited about translating the work we do in the lab to hospitals and one day having an impact on patient care worldwide.”

GUILLERMO AMEER DANIEL HALE WILLIAMS PROFESSOR OF BIOMEDICAL ENGINEERING AND SURGERY

The human body has the remarkable ability to heal and repair itself throughout its inhabitant’s lifetime. But sometimes, it can use a little help.

Enter regenerative engineering. This rapidly expanding, interdisciplinary field aims to jumpstart the growth of injured, missing, or diseased organs and tissue. It also promises to minimize, if not eliminate, many of the issues that challenge medical care providers the most, ranging from a shallow donor pool to the full spectrum of potential surgical complications.

“There’s an unmet need for better solutions,” says Guillermo Ameer, the Daniel Hale Williams Professor of Biomedical Engineering and Surgery and a pioneer in the field of regenerative engineering. Over the past 15 years, Ameer and his team at Northwestern have stood at the forefront of this revolutionary science, developing a range of biomaterial solutions to promote healing and improve patients’ quality of life.

Ameer believes he’s only glimpsed what’s yet to come.

A pioneer in an evolving field

Regenerative engineering, which evolved from tissue engineering, draws researchers from advanced materials science, stem cell and developmental biology, and clinical translation to develop new tools capable of regenerating organs and complex tissues.

“At its core,” Ameer says, “it’s a convergence of disciplines to help patients.”

Ameer’s research group focuses on developing novel advanced liquid and solid-bound materials based in citric acid, a compound already present in the human body. The biomaterials, which range in size from nanoscale to macro dimensions, can be engineered to become scalable and reproducible tools specifically designed to promote tissue and organ regeneration in patients. The applications cover a host of issues ranging from cardiovascular disease and diabetes to torn ligaments and bladder disease.

As one example, Ameer’s group developed a “regenerative bandage” to address chronic, non-healing diabetic foot ulcers, which affect about one in seven diabetics. The ulcers can lead to lower-leg amputation or even death. Ameer’s solution healed the diabetic wounds four times faster than a standard bandage and without any of the traditional side effects.

In other research, Ameer’s team repaired a hole in a mouse’s skull by regrowing “quality bone,” a breakthrough with the potential to help those suffering severe head trauma. They also created the first-ever inherently antioxidant biodegradable

biomaterial, a groundbreaking development that minimizes the negative effects often associated with a surgical implant or medical device placed inside the body.

“We develop materials from scratch and work directly with users and industry to implement the materials into potential products,” says Ameer, who has published more than 250 scientific papers and has more than 45 patents issued or pending in nine countries. He has also conducted research in drug and gene delivery, patient-specific medical devices, and stem cell engineering.

“I’m excited about translating the work we do in the lab to hospitals and one day having an impact on patient care worldwide,” he says.

At a crossroads

Though regenerative engineering is expanding in the United States and around the world—China and some European nations have made sizable investments in research centers and scholarship—Ameer says the field has reached a critical crossroads. While he and other investigators have unveiled promising innovations, additional scalable successes will be necessary to capture industry attention and propel broader impact.

“These therapies can be effective,” Ameer says, “but to date, we have not had the big success stories we need to justify the process and the cost to scale up.” Ameer hopes Northwestern’s new Center for Advanced Regenerative Engineering (CARE), which is slated to launch this summer with Ameer as its founding director, will supercharge the field.

“The center will help propel and disseminate the concepts of regenerative engineering to all stakeholders in the community, enabling the potential benefits of regenerative medicine for all,” Ameer says, noting that CARE’s advisory board includes industry representatives, investors, and physicians to help drive marketplace acceptance. “If we can facilitate translation and get companies and investors to see the promise of these innovative technologies, we have real potential to move quickly and eventually impact millions around the globe.”

Such momentum could ignite the entire field, particularly given the evolving integration of nanotechnology and biointegrated technologies. “In time, regenerative engineering can become another part of the information system and an extension of personalized medicine, consolidating data to enable clinicians to remotely control and monitor the status of regenerative treatments in real time.”

DANIEL P. SMITH

WEARABLES AND WELLNESS

ATHLETES, MILITARY PERSONNEL, AND STROKE PATIENTS TRY OUT STATE-OF-THE-ART WEARABLES TO BOOST PERFORMANCE, IMPROVE READINESS, AND SPEED REHABILITATION.



Northwestern bioelectronics pioneer John A. Rogers is collaborating with a widely diverse group of partners—including Gatorade, the Seattle Mariners and other professional sports teams, the US Air Force, and Shirley Ryan AbilityLab—to bring his stretchable electronic devices into widespread distribution.

His new microfluidic sweat analytics system measures sweat and sweat biomarkers, allowing users to monitor sweat rate and electrolyte loss. The information helps them keep hydrated, replenish their electrolytes, and stay on top of their game.

Developed in Rogers's Northwestern Engineering lab, the soft, flexible device sits on the skin and measures sweat to determine how the body responds to exercise—displaying the results with a simple, real-time visual readout. Launched by Rogers's group through Northwestern's Innovation and New Ventures Office (INVO), startup Epicore Biosystems has created large volume manufacturing capabilities for these microfluidic devices. It plans to co-package them with nutritional, skin health, cosmetics, and sports hydration products with future potential use in clinical medicine and rehabilitation.

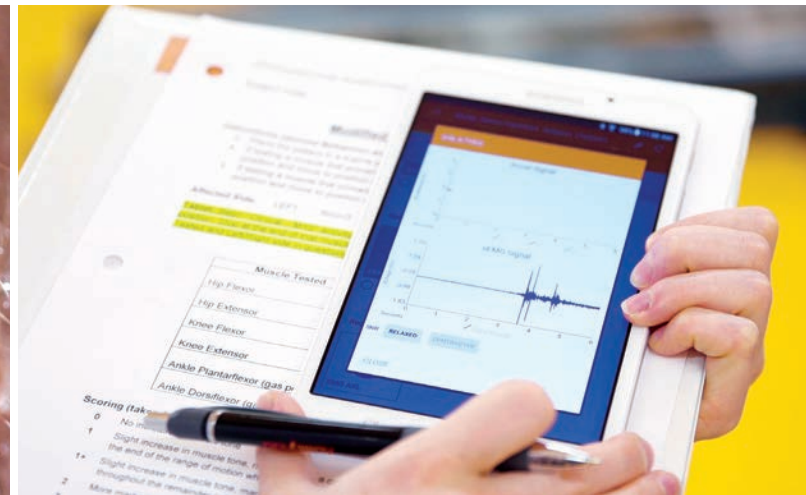
"The Gatorade Sports Science Institute knows a great deal about sweat, and they have very rigorous testing protocols for evaluating new technologies in this space," says Rogers, the Louis Simpson and Kimberly Querrey Professor of Materials Science and Engineering, Biomedical Engineering and Neurological Surgery in McCormick and Northwestern University Feinberg School of Medicine. Rogers is also the director of the Center for Bio-Integrated Electronics.

Lindsay Baker, principal scientist at the Gatorade Sports Science Institute, comments, "Our mission has always been to help athletes optimize their health and performance through research and education in hydration and sports science. Through our partnership with Epicore Biosystems, we're developing exciting new ways to measure and monitor sweat, which can help us better recommend hydration strategies for our athletes."

ON THE FAST TRACK

Initially introduced in 2016, Rogers's microfluidic design has come a long way in just a matter of months. Earlier designs measured chloride loss, glucose, lactate, and pH levels in sweat. Newer platforms also quantify concentrations of heavy metals such as lead and arsenic as well as urea and creatinine levels, the latter of which relate to kidney health. The latest devices can also measure these chemistries continuously, allowing wearers to monitor how their sweat chemistry changes during an exercise regimen and throughout the day.

Even better: athletes do not need to pause their workouts to decipher complicated information. Instead, they can monitor these sequentially changing levels with a simple glance. During exercise, sweat flows through the device's microscopic channels and into different compartments. In those compartments, reactions with chemical reagents result in visible color changes that quantitatively relate to electrolyte concentrations.



“Most people want to know if they are losing a lot of chloride, a little bit, or almost none,” Rogers says. “They can just eyeball the device and determine if their electrolyte levels are high, medium, or low.”

Another unique feature of these latest platforms is the ability to measure users’ sweat during aquatic sports, even when fully under water. New adhesive materials and microfluidic designs maintain watertight seals to the skin. Northwestern’s swim team now uses the system routinely during training and competition.

“We’ve been concerned about the impact of sweating on hydration and performance,” says Jarod Schroeder, head coach of Northwestern’s men’s swimming team, “but until now, we’ve had no way to make quantitative measurements. The remarkably high levels of sweat loss that occur in the pool demand careful scheduling for rehydration.”

BEYOND ATHLETICS

Active duty airmen at the Wright-Patterson Air Force Base in Dayton, Ohio, also have begun using the devices. “The ability to monitor sweat loss and sweat chemistry in situ on the skin is of interest because the data may allow us to more effectively manage military readiness under grueling conditions in training or on the battlefield,” says Jennifer Martin, a research chemist for the US Air Force.

Patients also are using the devices at Shirley Ryan AbilityLab, one of the nation’s top translational research hospitals. Researchers there are exploring left/right asymmetries in sweating as a metric for recovery in stroke patients. The devices also help clinicians monitor differences in patients’ sweat chemistry over the course of the rehabilitation process.

“The unique capacity to measure sweating across multiple body locations simultaneously opens up the possibility for using anomalous sweating as an indicator of recovery status.” says Arun Jayaraman, director of the Max Näder Lab for Rehabilitation Technologies and Outcomes Research at Shirley Ryan AbilityLab.

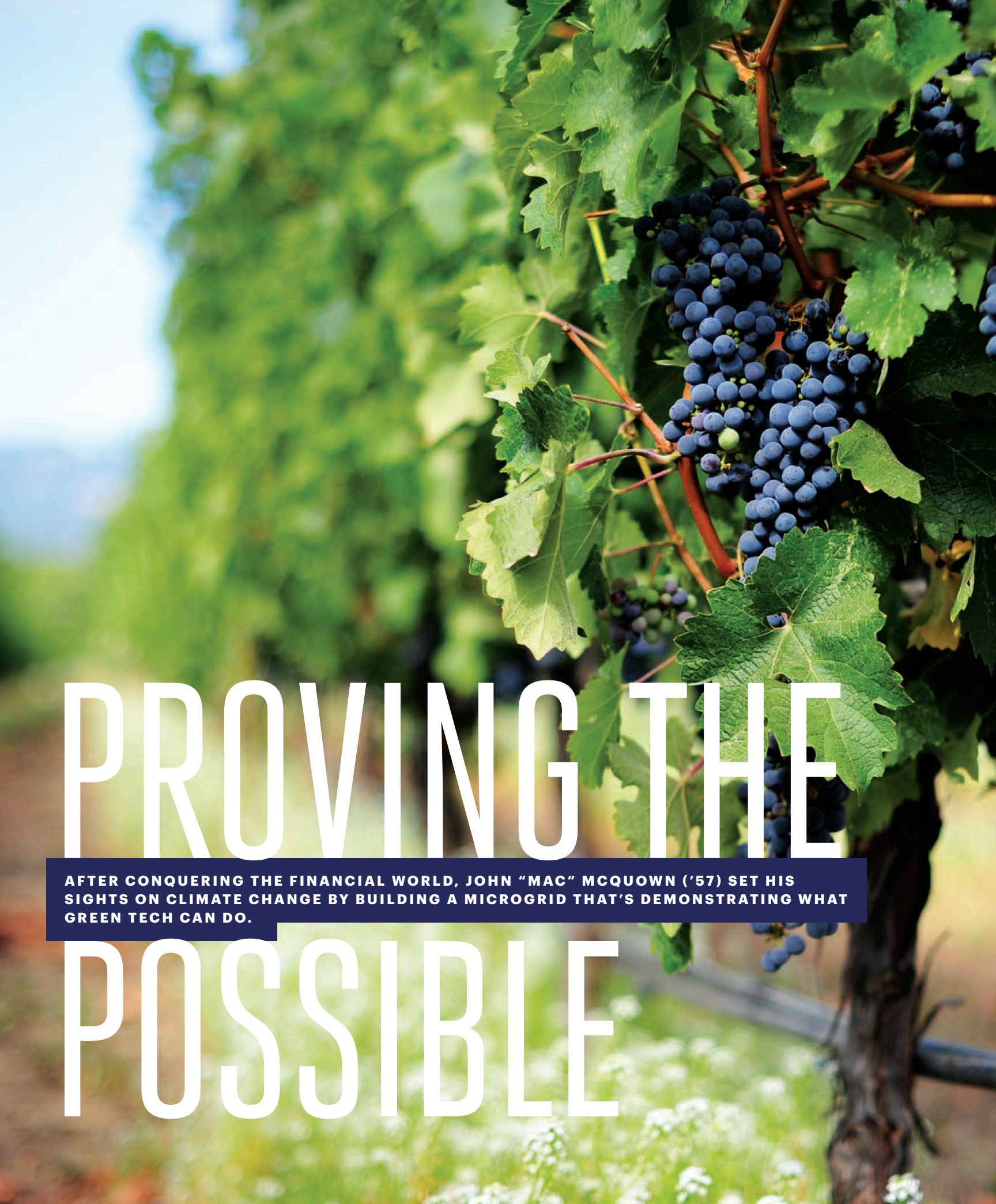
INNOVATION CONTINUES

Rogers and his team continuously search for new applications for wearable biometric technologies. Stroke patients are using a new bandage-like throat sensor Rogers’s group developed to measure swallowing ability and patterns of speech. The sensors aid in the diagnosis and treatment of aphasia, a communication disorder associated with stroke, and stream data wirelessly to clinicians’ phones and computers.

Because the sensors are wireless, patients can wear them even after they leave the hospital, enabling doctors to monitor how patients are functioning in the real world.

“Talking with friends and family at home is completely different from what we do in therapy,” says Leora Cherney, research scientist at the Shirley Ryan AbilityLab. “Having a detailed understanding of patients’ communication habits outside of the clinic helps us develop better strategies with our patients to improve their speaking skills and speed up their recovery process.”

AMANDA MORRIS AND KAYLA STONER



PROVING THE

AFTER CONQUERING THE FINANCIAL WORLD, JOHN "MAC" MCQUOWN ('57) SET HIS SIGHTS ON CLIMATE CHANGE BY BUILDING A MICROGRID THAT'S DEMONSTRATING WHAT GREEN TECH CAN DO.

POSSIBLE



"IF THE UNIVERSE HAS A SINGLE GENERATING FUNCTION, IT'S SERENDIPITY."

JOHN "MAC" MCQUOWN
FINANCIAL ENGINEER, ENTREPRENEUR,
AND ENVIRONMENTALIST

The stars always seem to align for John "Mac" McQuown. The financial engineer, entrepreneur, and environmentalist is fond of saying, "If the universe has a single generating function, it's serendipity."

The man renowned for pioneering equity index investing has built a career applying analytics to the business world. He also credits serendipity with taking him from the family farm in Sandwich, Illinois, to Wall Street and leading him back to the countryside again.

Today, the various roads of McQuown's journey intersect in Sonoma, California, at Stone Edge Farm, home to his thriving organic vineyard and winery as well as his innovative micro-grid technology testing ground. McQuown recently spoke with *Northwestern Engineering* about his commitment to the environment and how engineering thinking has guided him as he pursues his passions.

WORKING THE LAND

McQuown's connection to the environment began as a boy on the family's 1,200-acre farm in Illinois. Owned by his parents and run by his aunt and uncle, the farm was short-handed during World War II while many of the men fought on the front lines. Young Mac was put to work as a farmhand at only eight years old.

"I can tell you right now, that teaches you an awful lot about the environment," he says. "It's a complete hands-on kind of learning." The sensitivity of his aunt and uncle to the farm's ecosystem and their respect for the natural resources on which they relied had a huge impact on the young McQuown. Their philosophy of wasting nothing resonated with him.

Intrigued by the machinery used on the farm, he decided to study mechanical engineering at Northwestern, becoming the first in his family to attend college. It was a class in corporate finance recommended by two of his Phi Delta Theta fraternity brothers that altered the course of his life and led to a celebrated financial and entrepreneurial career.

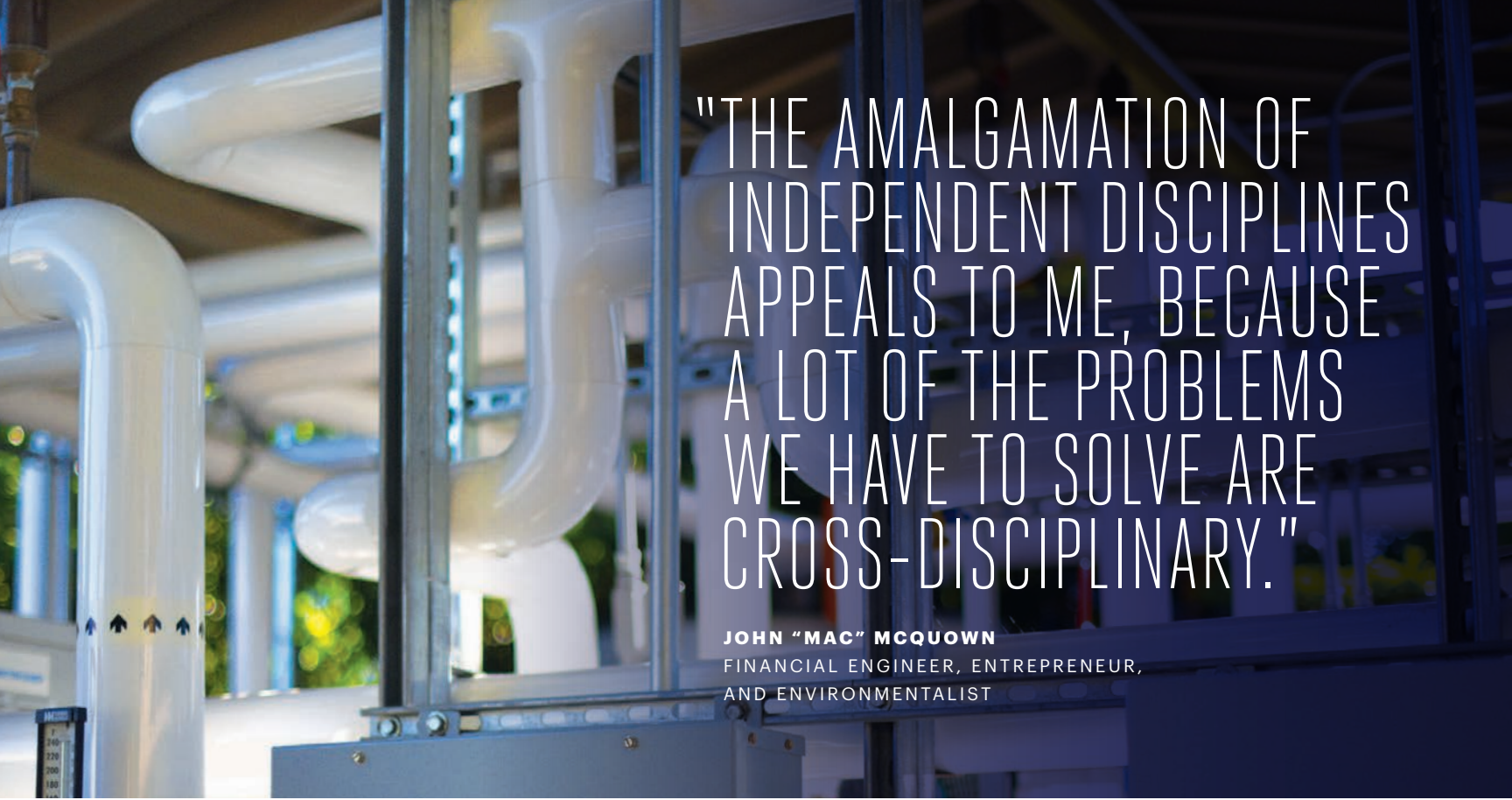
REVOLUTIONIZING INVESTMENTS

Perhaps the most serendipitous moment of McQuown's life happened when he walked into Professor Harry Guthmann's corporate finance class. Instantly drawn to the topic, McQuown was intrigued by the intricacies involved in financing enterprises. He enjoyed the course so much that the textbook he used—authored by Guthmann—is still a cherished possession.

"I discovered in that course that there was an enormous amount of complexity in the topic, and how sparse it was in analytic interpretation," he remembers. "It was very subjective, and I was surprised at that."

McQuown was hooked. After serving two years in the US Navy, he earned an MBA from Harvard Business School and pursued a career in quantitative finance. He began working on Wall Street with Smith Barney & Co. in 1961 and was again disturbed by how much subjectivity went into investment management.

Continuing to ponder the problem after joining Wells Fargo Bank in San Francisco, McQuown pioneered the use of data analysis to create the first equity index funds and launched a revolution in investing. The achievement earned him a place in finance history as "one of the architects of the modern investing system," according to *Bloomberg Markets* magazine.



"THE AMALGAMATION OF INDEPENDENT DISCIPLINES APPEALS TO ME, BECAUSE A LOT OF THE PROBLEMS WE HAVE TO SOLVE ARE CROSS-DISCIPLINARY."

JOHN "MAC" MCQUOWN
FINANCIAL ENGINEER, ENTREPRENEUR,
AND ENVIRONMENTALIST

AN AFFINITY FOR COMPLEXITY

McQuown went on to cofound Wells Fargo Investment Advisors, which is now part of investment management and financial planning firm BlackRock. Since leaving Wells Fargo in 1974, McQuown has used his data-driven approach to business to launch more than a dozen companies in the financial services, technology, and California fine wine industries. Successes include the corporate credit analytics firm KMV and investment management companies Diversified Credit Investments and Dimensional Fund Advisors.

Although these ventures may seem varied, everything McQuown engages in relates to his interest in complexity and the intersection of disciplines. "The amalgamation of independent disciplines appeals to me, because a lot of the problems we have to solve are cross-disciplinary," he explains. "They don't fit neatly into one academic discipline."

McQuown and his wife, Leslie, gifted funds to support Northwestern's Institute on Complex Systems and its research into the complexity in biological systems, markets, and innovation adoption in workplaces. He's also involved in Northwestern's finite Earth research, one of the strategic themes identified by the University's Global Strategy Task Force.

This affinity for complexity has been the common thread throughout his professional and personal endeavors, McQuown says. "My life has been an application of engineering and science to business, particularly to finance on one hand and winemaking on the other."

FROM SANDWICH TO SONOMA

Drawn back to the land in 1995 by his agricultural roots, McQuown and Leslie began purchasing the land that now makes up Stone Edge Farm. As he looked around their Sonoma, California, property trying to decide what to grow, grapevines seemed the obvious choice for the soil. With some industry experience under his belt from helping establish the Chalone Wine Group, McQuown set out to turn the property into a vineyard and winery.

Today, McQuown is proud of Stone Edge Farm Estate Vineyards & Winery's two Bordeaux-style wines: Stone Edge Farm Cabernet Sauvignon and Surround Red Bordeaux Blend. The 16-acre organic farm also produces olive oil and heirloom vegetables and has a restaurant.

From the beginning, McQuown's environmentalism and concern for climate change spurred him to make Stone Edge Farm sustainable and energy efficient. The respect for the environment he inherited from his aunt and uncle became part of the philosophy behind the farm.

CREATING A CLEAN ENERGY TESTING GROUND

McQuown ranks contributing to a solution to climate change as his top personal goal. His years working the land as a boy and sailing the oceans in the Navy gave him a passion for conservation. Serving on the Scripps Institution of Oceanography Advisory Board instilled an appreciation for the urgency of the issue, and many of his philanthropic endeavors are directed toward it.



Not satisfied to simply retire and hope for a solution, McQuown has gone one step further, putting skin in the game by developing a microgrid testing ground on Stone Edge Farm. “I decided to try to use evolving energy technology, starting with solar panels,” he explains. “When we turn photons from the sun into electricity, we can put it into a battery for later use, but we can also make hydrogen from rainwater. Hydrogen has by far the best energy density characteristics of any energy source, and it’s completely clean.”

McQuown and engineer Craig Wooster created the microgrid with the motto: “We prove the possible.” The idea was to create an “island” that can store energy indefinitely, access it instantly, and export it to the grid. The Stone Edge Farm microgrid has more than 20 distributed energy resources and nine different battery systems. In addition to solar panels, it also uses microturbine and hydrogen fuel cell technology. The microgrid generates clean electricity, reuses water, and creates fuel for zero-emission vehicles.

In island mode, the microgrid can sustain the farm completely with energy to spare. There have been times during emergencies when it was the only functioning power in the area. Excess power is available to the local power company.

The greater goal of the project is to demonstrate that clean energy solutions can power whole cities. Paid graduate student interns from all over the country come to study and contribute to the microgrid, and all intellectual property is open to free use. This year, the project received the California Governor’s Environmental and Economic Leadership Award.

“It’s a pretty astonishing accomplishment, to say the least,” McQuown says. “We’ve gotten a lot of people’s attention.”

INVESTING IN THE FUTURE

McQuown sees the decentralized microgrid approach to power as the way of the future, and calls the antiquated, centralized US power generation and distribution system obsolete and injurious to the environment. “How we get out from under that system will occupy a lot of brains in the next couple of decades,” he says, “but if we don’t, the environment will come down on us.”

In April, Northwestern Engineering held an event—called the Symposium on Microgrids: Renewable Energy Microgrids for Sustainable Development—where leaders in technology and policy assessed challenges to microgrid development and discussed opportunities to overcome them. The event was inspired by McQuown’s work in the area.

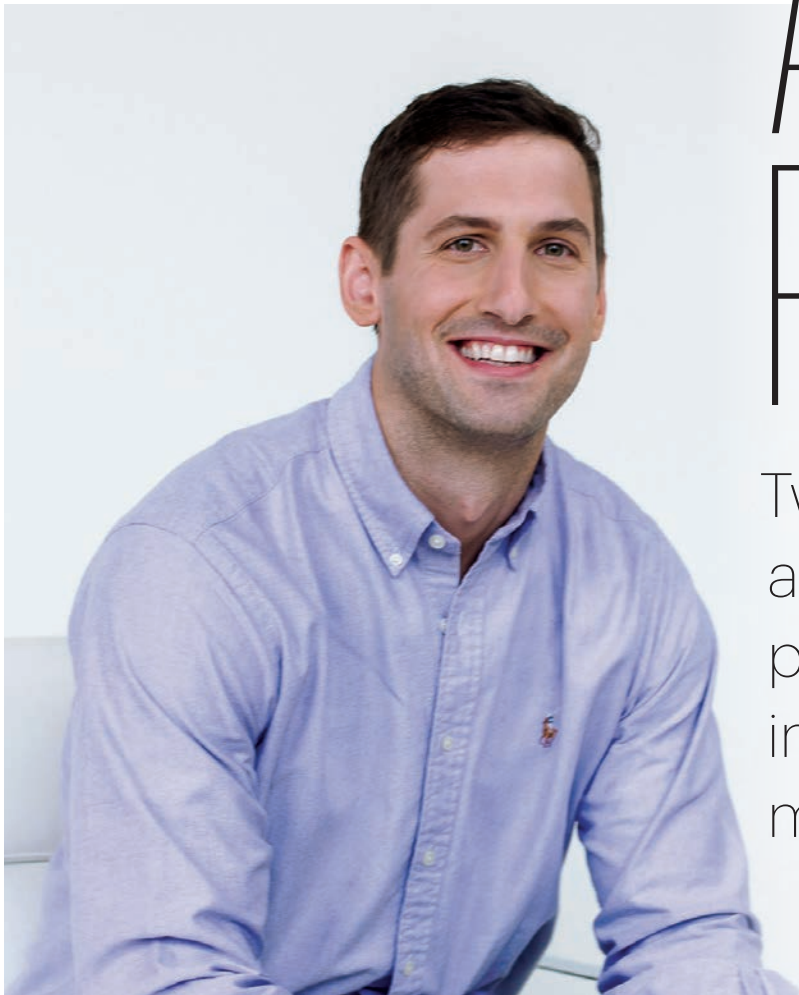
And while it may seem a world away from Wall Street, McQuown’s farm represents a cosmic coming together of many interests. He’s happy to share what they’ve learned there and encourages the students who will become tomorrow’s leaders of environmental and climate science to contribute.

That’s why staying involved with research at Northwestern is so important to McQuown, who received the 2017 Northwestern Alumni Medal and was the 2015 undergraduate convocation speaker. The lessons he learned at the University have echoed throughout his life. “I came out of Northwestern Engineering an awful lot smarter than when I went in,” he says. “It had a big influence on me.”

SARA LANGEN



BACK TO NATURE FOR A PURE POUR



Two Northwestern alumni—
and wine connoisseurs—
put a cork on wine
impurities and bottle up
marketplace success.

“Neither of us could’ve predicted this. We’ve both really been living in the journey and are now beginning to embrace the longer perspective.”

JAMES KORNACKI ÜLLO CEO

In 2015, James Kornacki had an idea—but no path for bringing it to market.

Inspired by his aunt’s sensitivity to sulfites and an earnest interest in using organic chemistry in practical ways, Kornacki wanted to find a way to remove sulfites from wine. With an estimated three million Americans sensitive to sulfites—an added chemical preservative necessary for wine bottling and storage, but extraneous once the bottle is opened—a solution would surely have marketplace appeal.

Kornacki began developing a filter that would restore wine to its natural, preservative-free state in tandem with his PhD work in the lab of Milan Mrksich, the Henry Wade Rogers Professor of Biomedical Engineering. He then brought the idea to a NUvention: Nanotechnology course, where interdisciplinary teams of students work collaboratively to bring nanoscience startups to market.

That’s also where Mike Marasco, director of the Farley Center for Entrepreneurship and Innovation, introduced Kornacki to Joe Radosevich, who was pursuing a master’s degree in chemical and biological engineering. Radosevich was no ordinary graduate student. He had a law degree, was a practicing patent attorney, and fittingly, was also a devoted wine connoisseur.

“In that wonderful Mike Marasco way, it was a polite introduction with a lot of social engineering behind it,” Kornacki says. “And it’s been a perfect match.”

Over the past three years, in fact, the pair has transformed Kornacki’s inventive creation into Üllo, a successful and fast-growing enterprise whose flagship product is a porous, food-grade polymer filter that selectively removes sulfites from wine without affecting other compounds, restoring its natural purity.

“Neither of us could’ve predicted this,” says Kornacki, Üllo’s CEO. Adds Radosevich, now Üllo’s chief technology officer, “We’ve both really been living in the journey and are now beginning to embrace the longer perspective.”

BRINGING INSPIRATION TO MARKET

That journey started gaining speed after the NUvention: Nano class team took on Kornacki as its client and started helping him refine his product’s value proposition. Meanwhile, a marketing course, orchestrated by the Farley Center, assisted Kornacki in charting a crowdfunding plan.

As he prepared to commercialize his product, Kornacki turned to Radosevich for help in bringing Üllo to market. Though Radosevich had spent four years of advanced schooling dedicated to

achieving a distinctly different goal, he jumped enthusiastically into the world of startups alongside Kornacki.

“You may only get a chance like this once in a lifetime, so I felt I had to do it,” says Radosevich, who is currently pursuing his Master Sommelier certificate. “I wanted to walk through the door and see what was on the other side.”

ENGINEERING THE LAUNCH

In August 2015, Üllo—which means “pure wine”—launched its online Kickstarter campaign. The company easily surpassed its initial \$100,000 target by raising \$157,404 from 1,423 backers. The following summer, Üllo shipped its first orders with an opening inventory of 25,000 units, an aggressive purchasing decision that could have sunk the company before it ever had an opportunity to gain marketplace traction.

“We trusted that the demand was there and prepared ourselves to fill orders,” Kornacki says. Soon after, national retailers such as Crate & Barrel, Brookstone, Bloomingdale’s, Best Buy, Sur La Table, and Whole Foods began carrying Üllo products. In its first 18 months, Üllo sold more than 100,000 purifiers and more than one million filters.

“It took a while to lay the necessary foundation, but there’s been incredible and rapid adoption since the product debuted,” Kornacki says. Last year, Üllo introduced two new products with its Florence decanter, inspired by the iconic Florence flask used by chemists, and the Ångström, a thoughtfully crafted wine glass named after one of the smallest scientific units of measurement. “A bit of chemistry humor,” Kornacki admits, adding that the umlaut in Üllo derives from a symbol alchemists use to describe purity.

In addition to its flagship \$80 wine purification product and red wine decanter, the Chicago-based company’s offerings also include custom wine glasses and a carafe for white wine. Having penetrated the domestic market, Üllo now looks to expand internationally. It recently began selling at high-end retailers in the United Kingdom and is on track to appear in stores in South Africa and Australia by year’s end.

“We’ve seen the appeal everywhere people drink wine, and I think we’ve barely scratched the surface of where we can be,” Kornacki says, calling his entrepreneurial journey with Üllo the most “Darwinian of experiences” he’s ever encountered. “That’s why Northwestern was so critical. The resources, perspectives, and support we encountered there combined to give us a competitive advantage and a powerful launching pad for Üllo.”

DANIEL P. SMITH



SAFE PASSAGE

The desire to create meaningful change fuels **JADINE CHOU**'s efforts to ensure student safety and security at Chicago's public schools.

Many people talk about making a difference, but Chicago Public Schools Chief Safety and Security Officer Jadine Chou ('86) is actually doing it. For more than six years, she and her team have dedicated themselves to ensuring the safety of more than 370,000 students on CPS campuses.

"I can't think of anything more important than the safety of children," Chou says. "I finally have the opportunity to do the best I can to make a difference."

The desire to improve the lives of others is a powerfully motivating force, Chou says. For her, the desire came after she earned an MBA and built a promising career in executive and management roles with Fortune 500 companies such as Kraft Foods, Motorola, and AT&T. Despite feeling comfortable in the corporate world, she sensed something was missing.

While researching ways to help the disadvantaged, Chou saw a job opening for the Chicago Housing Authority and felt it was just the kind of work she wanted to do. She joined the CHA in 2007 as a properties portfolio executive and quickly worked her way up to senior vice president.

While overseeing 17,000 public housing units, security was a large part of Chou's job. She realized community involvement was key, so she engaged CHA residents in her initiatives with the Chicago Police Department, resulting in an overall 20 percent reduction in serious crimes across the properties. "It was one of the most important parts of my job. If families aren't safe, what else matters?" she asks.

Chou enjoyed her work with the CHA and had no intention to leave when CPS contacted her in 2011. Still, she found the prospect of helping even more people through the school system compelling and accepted the offer.

Today, she approaches her job from an engineering perspective, as she has throughout her career. "Northwestern trained me to define the problem I'm trying to solve, rather than jumping to the solution," she explains. "When we have consensus on what the problem is, we can sit down and work on how to solve it and get to the root of the issue."

Instead of focusing on punishment in instances of misbehavior, Chou's team considers what may be causing the problem, or what factors in students' lives contribute to their behavior. This active, supportive approach has shifted the perspective of safety in schools.

"It takes more effort to do it this way," Chou says. "Many might want to take the approach to just suspend the student, but that doesn't solve anything—certainly not for the child, and long-term, not for the school."

Chou's major initiative is the Safe Passage program, which provides supervised routes to 159 schools, serving more than 75,000 students. The program has reduced criminal incidents along the way by more than 30 percent in five years. It's an example of the difference that Chou wanted to make in the city. "I find it extremely rewarding that we can help students navigate through challenges, hoping that we've played a role in helping to make a difference in their lives."

SARA LANGEN



“I wanted computer science in the schools because it’s engineering thinking, and everyone needs to be a critical thinker. We’d have a much better citizenry if we taught everyone to think critically.”

Computer Science for All

ENGINEERING THINKING FUELS **BRENDA DARDEN WILKERSON**’S MISSION TO INCREASE ACCESS TO TECHNOLOGY EDUCATION AND CAREERS, PARTICULARLY FOR WOMEN.

Often throughout her career, Brenda Darden Wilkerson (’85) has been the only woman or the only person of color in the room. As a Black woman in tech, she knows what it’s like to feel alone in the field.

Today, Wilkerson uses her experience to advocate for access, opportunity, and social justice for underrepresented communities in tech. As president and CEO of AnitaB.org (formerly known as the Anita Borg Institute for Women and Technology), a non-profit organization dedicated to connecting, inspiring, and guiding women in computing, she helps millions of women around the world.

“I’ve been a female technologist—I know the struggles and challenges,” she shares. “When we have people of different ages with different backgrounds and experiences at the table, we create a much richer experience.”

While the tech industry continues to grow, fewer women choose to enter the field. According to research by Accenture and Girls Who Code, the presence of female computer scientists in the workforce has dropped from 37 percent in 1995 to an estimated 24 percent today.

Wilkerson hopes to reverse that trend through her work at AnitaB.org. In fact, she has worked to democratize computer science since teaching computing courses for adults at Wilbur Wright College in Chicago in 1992. She soon became director of Wilbur Wright’s IT training, where her work captured the attention of Chicago Public Schools leadership, who recruited her in 2009 to serve as the system’s director of computer science and IT.

While there, she spearheaded the Computer Science for All program, an initiative to increase access to computer science education for students at all grade levels as a basic part of the curriculum. “Technology often feels like an elite sport, and there’s no reason for it to be that way,” Wilkerson says.

The program caught the attention of the Obama administration and Wilkerson got to help launch Computer Science for All programs across the country. “To have President Obama’s people come and say, ‘We want to do that, too’—I’m humbled when I think about it,” she says. “I’m just so grateful for his leadership.”

Wilkerson hopes to channel that experience to help reverse the declining role of women in the tech sector with the goal of increasing their presence to 50 percent. “Women should be represented as we are in culture,” she says. “Everybody who has the aptitude and is willing to work toward the goal of using tech to solve the problems of mankind should have a place at the table.”

By using engineering thinking for social impact, Wilkerson seeks to create a better world. “I wanted computer science in the schools because it’s engineering thinking, and everyone needs to be a critical thinker,” she says. “We’d have a much better citizenry if we taught everyone to think critically.”

SARA LANGEN

Better Design through Data

DEAN MALMGREN AND MIKE STRINGER (BOTH PHD '09) JOIN IDEO TO EXPLORE CREATIVE WAYS TO REALIZE THE POSITIVE POTENTIAL OF DATA SCIENCE.



Dean Malmgren and Mike Stringer are data guys—at least, that’s how they were perceived. It’s not hard to see why—they completed their PhDs in the lab of Professor Luis Amaral, where they conducted data science research, and then, in 2009, started a company called Datascope Analytics, where they hired data scientists to solve data problems for clients.

There was only one issue.

“There’s no such thing as a data problem,” Stringer says. “Looking only at the data from the outset throws away a huge part of how you solve a problem. The data is actually just one resource for design thinking.”

Turns out they were designers all along, but now it’s official. After eight years of success, Datascope was acquired by design firm IDEO in October 2017. Though the two companies had partnered on projects for years, the acquisition brings together design and data to tackle the next frontier: augmented intelligence.

GETTING THEIR “MBA ON THE STREETS”

Malmgren and Stringer hadn’t predicted this path when they were finishing their PhDs. The two knew they had a specific set of skills that was in demand: they knew how to work with data, and they knew how to communicate their results.

“Working in the Amaral lab, the idea of communicating science was not secondary,” Stringer says. “We practiced it all the time. We always kept the audience in mind while doing our research.”

As they finished their degrees, the two would walk around campus and talk about starting a data science business—how they would structure it, how they would get started. Eventually they turned to Mike Marasco, director of the Farley Center for Entrepreneurship and Innovation, for help. He set them up in an incubator and offered advice. Soon, the first clients came rolling in.

From there, they opened their first official office in Chicago, where they earned their “MBA on the streets,” as Malmgren puts it. As founders of a bootstrapped startup, Malmgren and Stringer were all in, but when they hired their first employee, the pressure was on.

“There’s no such thing as a data problem. Looking only at the data from the outset throws away a huge part of how you solve a problem. The data is actually just one resource for design thinking.”

MIKE STRINGER

“We were either going to make this happen, have reasonable salaries and work/life balance, or we weren’t,” Malmgren says. “Hiring employees added a lot more incentive to make sure we didn’t screw it up.”

As they worked on projects across the board—helping Procter & Gamble find and connect subject-matter experts within the company, helping Oracle predict solutions for hardware failure—they became better at articulating what exactly they did. “Our clients usually came to us with a too-narrow problem definition or a too-narrow idea of how they wanted to solve it,” Malmgren says. “That was usually an indication that there was room to learn about what the real nature of the problem was. We practiced human-centered data science, and we approached problems with a design process.”

WHAT WOULD IDEO DO?

With this design-thinking mindset, Malmgren and Stringer regularly turned to IDEO for inspiration. They had become friends with IDEO Chicago partners Iain Roberts and Andrew Burroughs, who served as early mentors and collaborators with Datascope on projects. When faced with a client problem that seemed insurmountable, the first question Malmgren and Stringer would ask themselves was, “What would IDEO do?”

As their company grew, the two faced new challenges. They hired more employees, moved to an office in downtown Chicago, and experienced “unstructured growth.” Once the company hit 10 employees, the co-founders realized they needed a new method of organizing projects and responsibilities.

“We had a moment where we realized we had to mature as a business,” Malmgren says. “We were stressed out. We had everyone trying to do everything.” It became clear that they were in essence a one-discipline firm that needed to grow other design disciplines.

Coincidentally, they began talking with IDEO about working together, and they realized the value that lay in interdisciplinary teams. They thought back to their time in the Amaral lab, which they said was “truly interdisciplinary,” and relished the idea of working across boundaries to design solutions to problems. “Luís always had 20 different projects going across many fields,” Stringer recalls.

Both firms realized that to create those teams, they needed to do it as one entity. IDEO acquired Datascope and launched its new effort: Design for Augmented Intelligence (D4AI).

GIVING PEOPLE SUPERPOWERS

The initiative comes at an interesting time in technological innovation. Machine-learning algorithms have advanced far enough to be considered “intelligent,” but much of what is said about these technologies is negative—how algorithms can make mistakes, or be prejudicial, or make opaque decisions that cannot be understood. Malmgren and Stringer, however, see this technology as an opportunity to create positive impact not by creating artificial intelligence, but rather by augmenting human intelligence.

“We want to create intelligent systems that work for people rather than against them,” Stringer says. A representative project is a personal service to help people manage their health. Such a program could use data and machine-learning algorithms to understand what interventions might work best to keep a person healthy. “We don’t want to change what they’re doing,” Malmgren says. “We want to give them superpowers.”

Malmgren and Stringer and their Datascope team are already working on a number of projects like this at IDEO (projects they can’t yet talk about). “We’re working on exciting projects that we didn’t have a chance to contribute to before,” Malmgren says. “Going from the Amaral lab to Datascope to IDEO—we have used the same problem-solving approach. Our focus and scope is just changing, and that’s what keeps it exciting.”

EMILY AYSHFORD

WE WILL.

THE CAMPAIGN FOR NORTHWESTERN

Northwestern University launched the multi-year We Will campaign in March 2014. Here are some recent notable gifts to Northwestern Engineering's campaign.

Thomas F. Baltutis ('75, '80) and **Jennie Baltutis** made a \$100,000 bequest provision to Northwestern University, establishing the Baltutis Family Endowment Fund.

Delfo Bianchini ('79) and **Francine Bianchini** pledged \$100,000 to support Northwestern Engineering through the McCormick School Annual Fund.

The **Farley Family Charitable Foundation** made a contribution to the Farley Director's Endowment Fund. The gift will provide programmatic, director, and clinical chair support for the Farley Center for Entrepreneurship and Innovation.

Robert C. Feldmann ('76) and **Barbara J. Feldmann** pledged \$200,000 for expendable and endowed undergraduate research fellowships. Undergraduate participants will be known as the Robert and Barbara Feldmann Fellows.

Melville H. Hodge ('52) and the late **Jane Smith Hodge** ('52) made a significant bequest provision to endow EXCEL, an academic summer program for incoming engineering freshmen. During the summer before their first year at McCormick, EXCEL students live on campus and participate in academically rigorous coursework, including leadership classes that help prepare them for their engineering education. EXCEL participants will be known as Melville and Jane Hodge EXCEL Scholars.

Reginald Jones, III ('15 P) and **Sarah Jones** ('15 P) pledged \$100,000 to establish the Greenbriar Equity Group Undergraduate Transportation Research Fellowship Fund.

Adam Karr ('93 Trustee) and **Tonia Karr** (Trustee SP) pledged \$2 million to endow the Karr Family Professorship in Computer Science and another discipline as part of CS+X, a cross-disciplinary initiative that creates transformational partnerships between computer science and other fields. The professorship is also supported by **Patrick G. Ryan** (KSM '59, '97 P, '00 P, '09 H, Trustee) and **Shirley W. Ryan** (WCAS '61, '97 P, '00 P, Trustee SP) through the Ryan Family Chair Challenge, which matches gifts made by other Northwestern supporters to establish new endowed professorships or chairs. With this gift, the Karrs' total commitment to the "We Will" Campaign is \$4 million.

Priscilla Marilyn Lu (PhD '80) and **Dwight Hill** pledged \$100,000 to Northwestern Engineering for the McCormick School Dean's Fund.

Edgar Vithal Menezes ('79, '80) and **Kristina Menezes** pledged to support Northwestern Engineering undergraduate research fellowships aimed at increasing undergraduate student interest in pursuing a PhD in materials science. Additionally, they are supporting improvements to the Materials Science Teaching Lab.

The **Porges Family Foundation** made a \$220,000 contribution to Northwestern Engineering for the McCormick Research Catalyst Awards Fund and the McCormick School Dean's Fund. Collectively, previous catalyst awards from the Porges Family Foundation have led to 39 publications, 33 research proposals, more than \$6.7 million in federal research grants to Northwestern, and three invention disclosures.

To celebrate their parents' (Professor Charles H. Dowding and Jane Dowding) love of all things science, engineering, and Northwestern, members of their family, including **Katherine D. Shoemaker** ('95), **Raleigh Shoemaker, Jr.**, **Christy Nicholas**, and **Peter Nicholas, Jr.**, established the Dowding Endowed Family Fund with a pledge of \$250,000 for Women in Engineering at Northwestern.

Michael R. Walsh ('83) pledged \$100,000 to Northwestern Engineering to support the Farley Director's Endowment Fund at the Farley Center for Entrepreneurship and Innovation.

An **anonymous donor** made a \$100,000 bequest provision to Northwestern Engineering in support of Vadim Backman's research in early detection of cancer.

If you would like to join in making a special gift to the campaign, please contact Patrick Hankey, development director, at 847-467-2950 or patrick.hankey@northwestern.edu.

Northwestern's Homecoming and Reunion Weekend is October 11-14. If you're a member of an undergraduate class that graduated in a year ending in 3 or 8 from 1958 to 2013—plus the Class of 2017—then this is your reunion year. Pull out your purple, gather your friends, and join fellow Wildcats back on the campus you've always called home. All alumni are welcome at Homecoming events, including Saturday's football game against the Nebraska Cornhuskers. Visit alumni.northwestern.edu/reunion to learn more.

IDEAS M

"Why did he come to Copenhagen?" Margrethe Bohr's question rings at the heart of Michael Frayn's 1998 Tony Award-winning play *Copenhagen*. No one disputes that German nuclear physicist Werner Heisenberg visited Bohr's husband Niels on a September night in the middle of World War II. But why he visited or what the two physicists discussed has been a source of controversy ever since.

This past April, three actors—including Northwestern Engineering professor Matthew Grayson—explored that mysterious conversation in a production of *Copenhagen* to mark the tenth anniversary of ETOPIA: Engineering Transdisciplinary Outreach Project in the Arts. Founded by Grayson, ETOPIA seeks to inspire cross-disciplinary dialogue about the role of science and technology in society.

ETOPiA also produced *Copenhagen* in 2008 as its inaugural offering. "We wanted to celebrate ETOPIA's tenth anniversary with something special, and this play is near and dear to our hearts," says Grayson, who reprised the role of Heisenberg, which he played in the 2008 production. "It's smart science and smart playwriting."

Photograph by Joel Wintermantle

IN MEMORIAM

Mr. Frank F. Broad '41
Mr. Jay L.A. Lembeck '43
Mr. William C. Jakes '44, '47, '49
Mr. Alan R. Lillie '44
Mr. Russell T. Ryan '44
Mr. Rabun M. Wood, Jr. '46
Mr. George R. Jarvis '48
Mr. Robert W. Scholler '48
Mr. Roland B. Calhoun '49
Mr. Rudolph Gorishek '49
Mr. Richard A. Randall '49

Mr. John L. Burton '50
Mr. Richard G. Cleaveland '50
Mr. Carmen P. Germano '50
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A CLOSER LOOK

In fall 2017, professor Marc Walton (second from right) led a course that challenged engineering and humanities students to use research techniques in materials science, archaeology, and museum studies to examine Egyptian mummy portraits. Co-taught by Taco Terpstra, assistant professor of classics and history at Northwestern, the course taught students to use non-destructive imaging and computational imaging techniques to determine the types of paint used in the portraits. The team's findings were on display at the Block Museum's exhibit, "Paint the Eyes Softer: Mummy Portraits from Roman Egypt," which ran through April 2018. See more on page 14.