McCormick School of Engineering and Applied Science

NORTHWESTERN ENGINEERING

FALL 2021

BACK ON CAMPUS

ENGINEERS CELEBRATE A RETURN TO NORTHWESTERN

WELCOME BACK, ENGINEERS

On September 17, Northwestern Engineering celebrated its return to campus on the plaza of the Technological Institute by formally welcoming its class of 2025 to “An Afternoon with McCormick.” Part of the University’s weeklong Wildcat Welcome orientation, the event allowed new Northwestern engineers to meet with student and faculty leaders from a variety of student groups, including the McCormick School of Engineering’s chapter of the National Society of Black Engineers, Develop + Innovate for Social Change, and the school’s Formula and Baja racing teams. Students met their new peers, showcased their latest projects, and discussed their goals for the year.

Photography by Matthew Allen

DISC

"Collaborations have been a hallmark of Northwestern Engineering for years, and in this issue, you will find stories that reveal the results of those connections."

GREETINGS FROM NORTHWESTERN ENGINEERING

The halls of Tech once again came to life this fall, as our students, faculty, and staff returned to campus. It has been a most welcome change. Though everyone has been incredibly resilient during the pandemic—our faculty and staff worked hard to continue our missions of education and research, and our students adapted remarkably quickly to online education—it is a morale booster to gather together again.

Many of our best ideas and collaborations are unplanned—a chance meeting in a hallway, in a classroom, or an offhand conversation at an event. These loose connections are difficult to replicate virtually. In an academic culture that thrives on ideas connecting with other ideas, connections like this often grow into full-fledged networks. Though we remain diligent in our safety measures, I look forward to seeing what our renewed in-person connections create this year.

Collaborations have been a hallmark of Northwestern Engineering for years, and in this issue, you will find stories that reveal the results of those connections. Our longstanding collaboration with the Field Museum, for example, has revealed new insights about lunar soil and led to a new paleobiology game for children. Our connection with the School of Communication has helped bring artistic thinking to computer science students, and teamwork among student groups has helped round out an engineering education, teaching students skills that they will use throughout their lives.

Our faculty are thriving. Professors in the Department of Industrial Engineering and Management Sciences, a field deeply grounded in optimization, have found success leading machine learning. Several other faculty members are leading the way in their fields—Hani Mahmassani in transportation and Ed Colgate in robotics and haptics—while Guillermo Ameer is celebrating the release of a new medical device that incorporates 20 years of work in biomaterials.

We have learned a lot over the past two years, including the importance of celebrating our accomplishments, big and small, in the face of difficult times. I celebrate our ongoing perseverance and our recent re-convergence, and I look forward to a future full of hope and opportunity.

As always, I welcome your feedback.

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

On the Cover Students celebrate a return to campus at "An Afternoon with McCormick" on September 17.

Photography by Matthew Allen

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Northwestern | McCORMICK SCHOOL OF ENGINEERING

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22


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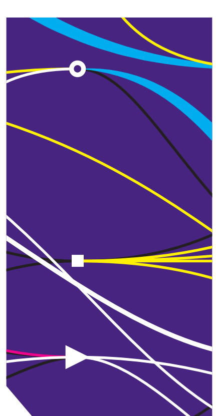
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38

NORTHWESTERN ENGINEERING
FALL 2021

NEWS

NORTHWESTERN PLANS MULTIMILLION-DOLLAR TECHNOLOGY ACCELERATOR

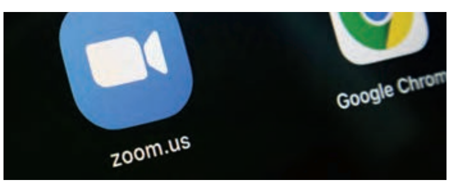
"This investment, by the state and Northwestern, will help create new tech companies and new jobs in Evanston and will repay us many times over in future prosperity for our community."

MORTON SCHAPIRO Northwestern President

A new multimillion-dollar technology accelerator in downtown Evanston will support startup companies led by Northwestern faculty in health, life sciences, and related fields. By offering laboratory space, networking opportunities, and management training, the accelerator will amplify scientific discovery and innovation to address the world's biggest problems.

As home for Northwestern's highly entrepreneurial faculty, the collaborative space will support commercialization of sophisticated scientific discoveries and help bring economic growth and new opportunities to the Evanston and Chicago communities.

World-renowned materials scientists John Rogers and Mark Hersam will be the first to occupy the new space. To foster technology-based economic development, the Illinois General Assembly appropriated $50 million of the state's 2022 capital budget for this project. Kimberly K. Querrey ('22, '23 P), chair of the Innovation and Entrepreneurship Committee of Northwestern's Board of Trustees, was so committed to the idea that she made a $25 million personal gift to Northwestern to help make the accelerator a reality.



ETOPiA Zoom Play Reflects Present-Day Research Realities

The Engineering Transdisciplinary Outreach Project in the Arts (ETOPiA) premiered "Science Under a Pandemic," two original one-act plays written by Northwestern graduates and directed by John Gawlik on April 9. Commissioned to be performed via a Zoom-like web interface, the plays explore original humanizing perspectives on research impacted by the COVID-19 pandemic outbreak.

The first play, *Breaking Point*, tells the story of an ambitious senior in engineering trapped overseas at the University of Cambridge who wants to put out world-changing work. The second, *The Little World*, is about an immunologist who struggles with the consequences of COVID-19 and how it affects her outlook on life and family. Matthew Grayson and Pedram Khalili served as the show's executive producer and co-producer, respectively. Josiah Hester assisted with publicity. All three are Northwestern professors.

$5

Cost per dose using the iVAX platform developed by Michael Jewett and Neha Kamat to produce conjugate vaccines to protect against bacterial infections

20,000

Number of chemical structures in a new Northwestern dataset of quantum-chemical properties for metal–organic frameworks

MCCORMICK GRADUATES CELEBRATE 163RD COMMENCEMENT

Northwestern Engineering celebrated the graduation of its Class of 2021 on June 13 as part of the University's 163rd Commencement. Bachelor's, master's, and PhD graduates were honored during the ceremony at Ryan Field.

The University-wide commencement was held virtually on June 14. That event featured remarks from University president Morton Schapiro and a keynote speech delivered by McCormick School of Engineering alumna Gwynne Shotwell ('86, MS '88), president and COO of SpaceX.

At the separate Northwestern Engineering convocation, Dean Julio M. Ottino said graduation has always been his favorite day of the year, and that he is more optimistic than ever about the future. Keynote speaker Bruce Mau lauded the accomplishments of the Class of 2021, commending the graduates for how they pivoted to function remotely.

Spinoff Receives $21.3 Million to Manufacture COVID-19 Test

A new, highly sensitive, easy-to-use test for COVID-19, which requires a single swab and 15 minutes, has received $21.3 million from the National Institutes of Health (NIH) Rapid Acceleration of Diagnostics initiative. Northwestern Engineering professors Sally McFall and David Kelso led development of the device at Northwestern University's Center for Innovation in Global Health Technologies.

The point-of-care technology is being commercialized by Northwestern spinoff company Minute Molecular Diagnostics, which will use the NIH grant to ramp up production to 1 million test cartridges per month.

Called DASH (Diagnostic Analyzer for Specific Hybridization), the device is about the size of a cereal box—small enough to sit on a countertop or desk. The test uses a polymerase chain reaction technique that amplifies DNA, increasing incredibly small virus samples to detectable levels.

"A hallmark of Farley classes is the opportunity to connect with the real world and learn by doing."

Hayes Ferguson
Director,
Farley Center for Entrepreneurship and Innovation

100

Nanometer resolution a lens developed by Koray Aydin and Sridhar Krishnaswamy can print

Farley Teams Make Semifinals at Business Plan Competition

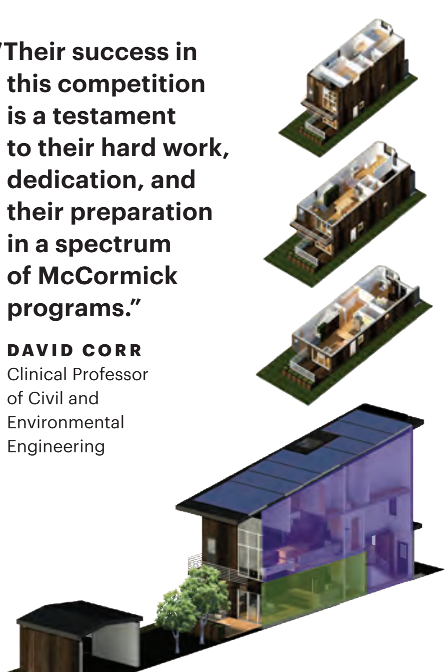
The Farley Center for Entrepreneurship and Innovation had a strong showing at this year's Rice Business Plan Competition. Three student teams with roots in the center competed in the competition.

Hubly Surgical and blip energy made it to the semifinal round, which included the top six teams from three different "flights." The at-home diagnostic solution startup Blue Comet Medical Solutions was awarded the $25,000 Southwest National Pediatric Device Prize and earned an additional $500 for the Mercury Fund Elevator Pitch Competition.

Hubly's cranial and orthopedic platform drilling solution focuses on modernizing bedside intracranial access, elective neurosurgeries, and elective orthopedic surgeries. To help renters buy into the green energy economy, blip designed equipment for storing energy when the price is low. Blue Comet offers an at-home diagnostic solution that tests for strep throat.

"Their success in this competition is a testament to their hard work, dedication, and their preparation in a spectrum of McCormick programs."

David Corr
Clinical Professor of Civil and Environmental Engineering



Student Team Wins DOE Solar Decathlon Design Challenge

An interdisciplinary team of Northwestern Engineering students called engiNUity was named 2021 Design Challenge Grand Winner (Residential Divisions) in the US Department of Energy Solar Decathlon.

The Solar Decathlon challenges the next generation of building professionals to design and construct high-performance, low-carbon buildings powered by renewable energy. The competition, which promotes student innovation, STEM education, and workforce development opportunities in the building industry, included 72 teams from 12 countries. Sixty-three teams were named finalists.

The winning NUHome concept, created by a group of 12 engineering undergraduates, includes efficient construction, a future-proof design, and natural light. The sustainable design, which earlier had won the Urban Single-Family Housing Division competition, is carbon-neutral and reduces consumption.

"The validation of the work we put in sparked a new pride in the completeness of our design and was a great burst of encouragement to compete for the grand award," says Andrea Lin, the project manager and design leader. "When we were announced as Residential Grand Winner, it just felt unreal."

DARIO ROBLETO ILLUSTRATES BOND BETWEEN SCIENCE AND ART

The marriage of science and art seems like it could be an awkward one. Science is about finding answers; art's purpose—to inspire, evoke, and communicate—is harder to define.

Nonetheless, the two disciplines can borrow from each other and even unite to tackle important cultural work, which Dario Robleto illustrated during his virtual Dean's Seminar Series lecture presented by Northwestern Engineering and the Mary and Leigh Block Museum of Art on April 8.

Robleto is a transdisciplinary artist and the McCormick School of Engineering's Artist-at-Large. Since assuming that post in 2018, he has spent much of his time working with faculty in Northwestern's Center for Synthetic Biology. That field has the potential to shape the future by finding ways to test for clean water, creating new proteins, and developing techniques to design targeted therapeutics or next-generation materials or chemicals.

Scientists and engineers involved in synthetic biology must, however, innovate in an ethical way. Honest, interdisciplinary discussions about ethics, Robleto said, are worthwhile and must be had. "It's not always a given that an artist and a scientist can have a really rich, deep conversation unless we work at it. I think the same goes for the public," he said.

"THE ARGUMENT FOR THE COLLABORATIVE VALUE OF ART AND SCIENCE HAS TO BE RESTATED, IT HAS TO BE CHAMPIONED ANEW, AND I THINK, VERY IMPORTANTLY, IT HAS TO KEEP ADAPTING WITH THE TIMES."

DARIO ROBLETO Transdisciplinary Artist and Artist-at-Large, McCormick School of Engineering

Investigators Collaborate with Ojibwe to Strengthen Resilience

A team of researchers that includes four Northwestern Engineering faculty members has been awarded a grant to address challenges faced today by the Ojibwe Nations.

The team received $50,000 in funding for its project, "Strengthening Resilience of Ojibwe Nations across Generations (STRONG): Sovereignty, Food, Water, and Cultural (in)Security," as part of the Civic Innovation Challenge, a competition led by the National Science Foundation in partnership with the US Department of Energy and US Department of Homeland Security. STRONG was one of 52 recipients of the Civic Innovation Challenge Stage-1 awards.

Researchers from the McCormick School of Engineering include (from left) Professors Josiah Hester, Aaron Packman, Jennifer Dunn, and William Miller. The project's vision is to co-create with Ojibwe communities methods to strengthen their future generations' resilience, integrating traditional ecological knowledge with data science, environmental science, social science, and engineering platforms.

"INCLUSIVE MAKING" HELPS STUDENTS DESIGN FOR PEOPLE WITH DISABILITIES

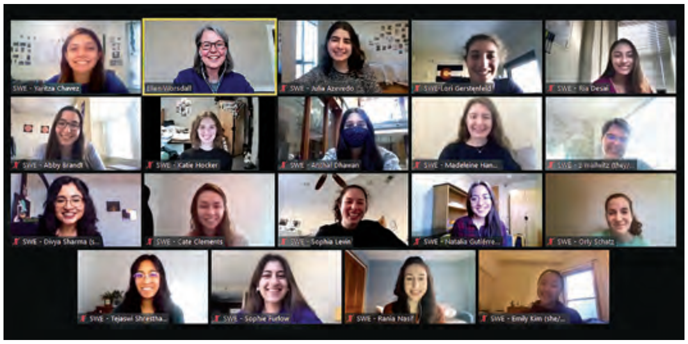
A Northwestern Engineering design course that takes a critical look at the field of "making" and includes partnerships between students and people with disabilities can promote accessibility in computing, according to Northwestern research.

The course, called Inclusive Making, serves as a preliminary blueprint for practitioners and researchers who want to adapt it for their own classes on accessible design, according to University researchers Marcelo Worsley and David Bar-El writing in *Computer Science Education* and the *International Journal of Child-Computer Interaction*.

PATH HELPS STUDENTS NAVIGATE NORTHWESTERN

As part of the One McCormick lecture series on May 12, Assistant Dean for Undergraduate Engineering Joseph Holtgreive explained how the Personal Academic Tactical Help (PATH) program, which aims to ease both academic and emotional struggles for students, has been even more valuable during the pandemic.

Created in 2016 by Northwestern Engineering's Office of Personal Development, PATH guides students through a sequential series of topics using an online portal and facilitated group discussions. The program aims to help students achieve intentional attention, healthy connection, self-compassion, and stress management, Holtgreive said. These goals, he noted, address issues like procrastination, feelings of isolation, self-criticism, and anxiety.



Virtual Career Day Explores Opportunities in STEM for Girls

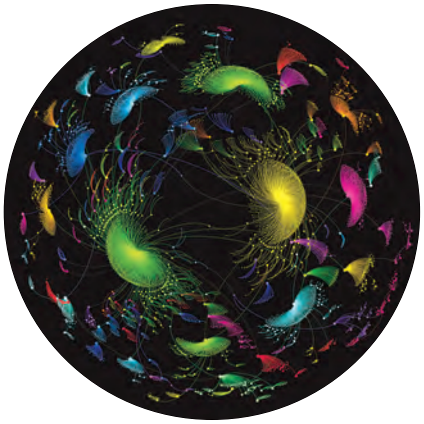
Northwestern University's 50th annual Career Day for Girls on February 27 drew 111 Chicago-area middle school and high school girls who took part in virtual design activities and panels. The career development and educational workshop, held each year as part of National Engineers Week, encourages young women to consider engineering in their education and career choices. "Engineering 4 Social Good" was the theme for this year's workshop, sponsored by Northwestern Engineering's chapter of the Society of Women Engineers.

1.5 TO 4.0 MICRONS

Length of sarcomeres in muscles studied by Wendy Murray and Julius Dewald that can disappear after strokes

4

Professors out of 12 featured in *Nature Materials* thematic issue on computational materials design



Open Quantum Materials Database Celebrates Milestone

Professor Christopher Wolverton's Open Quantum Materials Database (OQMD) supports new materials design by identifying candidate materials for applications like alternative energies and sustainability. The platform recently added its one millionth compound.

Launched in 2013, the OQMD can be used to narrow down materials candidates to a mere handful that require further experimentation. Users can search by composition, create phase diagrams, determine ground state compositions, and visualize crystal structures. The open-source system also uses machine-learning models trained on the database to predict the possible existence of new compounds that have not yet been synthesized.

Wolverton and other scientists have used the database to explore new materials that could advance their research in batteries, hydrogen, lightweight metals, fuel cells, and thermoelectrics.

ADAM LEUNG NAMED CO-OP STUDENT OF THE YEAR

Adam Leung completed his co-op with Hollister Incorporated, a medical device developer based in Libertyville, Illinois. During two co-op experiences, one before and one during the COVID-19 pandemic, Leung managed both academic study and full-time paid work. He collaborated with senior engineers to help develop the foundational materials behind innovative medical devices and platforms.

Leung also received the Cooperative Education and Internship Association's 2021 Cooperative Education Student Achievement Award, recognizing outstanding students who have excelled in or made significant impact in work-integrated learning. He is the first Northwestern Engineering co-op student to receive the honor.

LAB NOTES

"SWEAT STICKER" DIAGNOSES CYSTIC FIBROSIS IN REAL TIME

A research team led by Professor John Rogers and including Professor Roozbeh Ghaffari has developed a novel skin-mounted sticker that absorbs sweat and then changes color to provide an accurate, easy-to-read diagnosis of cystic fibrosis within minutes.

While measuring chloride levels in sweat to diagnose cystic fibrosis is standard, the soft, flexible, skin-like "sweat sticker" offers a stark contrast to current diagnostic technologies, which require a rigid, bulky, wrist-strapped device to collect sweat.

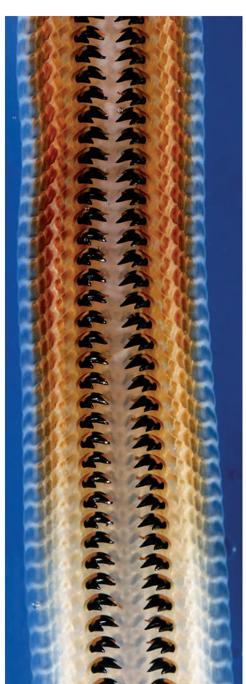
After developing the sweat sticker at Northwestern, the researchers validated it in clinical pilot studies involving cystic fibrosis patients and healthy volunteers at the Cystic Fibrosis Center at the Ann & Robert H. Lurie Children's Hospital of Chicago. The sticker showed enhanced performance in collected sweat volume and equivalent accuracy to traditional platforms.

The research and study findings were published as the cover feature article in the journal *Science Translational Medicine*. By softly adhering to the body, the millimeter-thick sticker makes direct but gentle contact with the skin without harsh adhesives.

"IN LIGHT OF THESE NEW CAPABILITIES AND FURTHER CLINICAL VALIDATION, CYSTIC FIBROSIS PATIENTS RECEIVING TREATMENT COULD SOMEDAY USE THE SWEAT STICKER AT HOME TO TRACK THEIR SYMPTOMS AND HYDRATION LEVELS DURING DAILY LIVING."

ROOZBEH GHAFFARI Research Associate Professor of Biomedical Engineering

Unexpected Find in Mollusk Teeth



To his surprise, Professor Derk Joester discovered a rare mineral within the teeth of a chiton, a large mollusk found along rocky coastlines. Prior to this finding, the iron mineral, called santabarbaraite, had been documented only in rocks.

The new finding improves researchers' understanding of how the chiton tooth can endure chewing on rocks to feed. Based on minerals found in such teeth, the researchers developed a bio-inspired ink for 3D printing ultrahard, stiff, and durable materials.

Among the hardest materials known in nature, chiton teeth are attached to a soft, flexible, tongue-like radula, which scrapes over rocks to collect algae and other food. Having studied chiton teeth extensively, Joester and his team most recently turned to Cryptochiton stelleri, a giant, reddish-brown chiton sometimes referred to affectionately as the "wandering meatloaf."

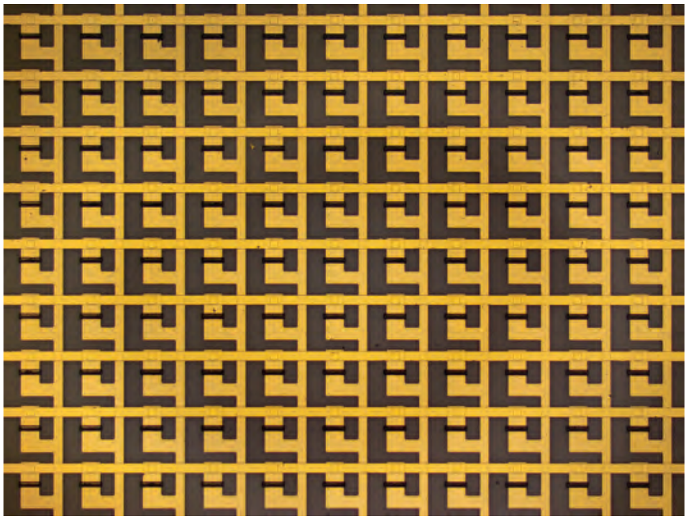
Joester's team collaborated with Argonne National Laboratory's Advanced Photon Source to use the facility's synchrotron spectroscopy capabilities and with the Northwestern University Atomic and Nanoscale Characterization Experimental Center.

5

Years the Center for Synthetic Biology has existed

$33 MILLION

Funding for researchers led by Jonathan Rivnay, Josiah Hester, and Guillermo Ameer to develop a wireless, fully implantable device that will control the body's circadian clock



NEW BRAIN-LIKE COMPUTING DEVICE SIMULATES HUMAN LEARNING

Professor Jonathan Rivnay and researchers have developed a brain-like computing device capable of learning by association. Similar to how Ivan Pavlov conditioned dogs to associate a bell with food, researchers at Northwestern Engineering and the University of Hong Kong successfully conditioned a circuit to associate light with pressure.

The device's ability lies within its novel organic, electrochemical "synaptic transistors," which simultaneously process and store information just like the human brain. Researchers demonstrated the transistor can mimic the short-term and long-term plasticity of synapses in the human brain. With its brain-like ability, the novel transistor and circuit could potentially overcome the limitations of traditional computing.

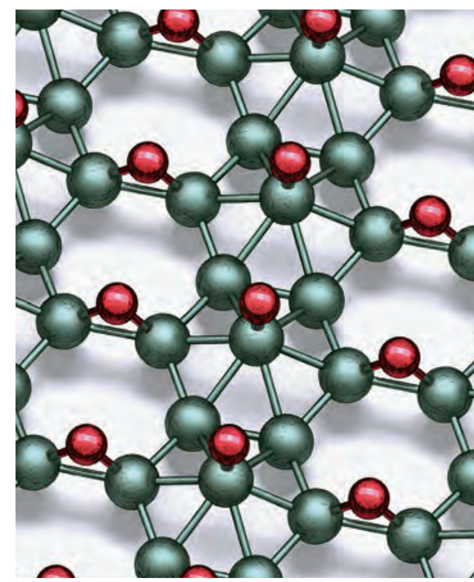
Scientists Stabilize Atomically Thin Boron for Practical Use

Researchers led by Professor Mark Hersam created borophane—atomically thin boron that is stable at standard temperatures and air pressures.

Researchers have long been excited by the promise of borophene—a single-atom-thick sheet of boron—because of its strength, flexibility, and electronic properties. Stronger, lighter, and more flexible than graphene, borophene could potentially revolutionize batteries, electronics, sensors, photovoltaics, and quantum computing.

Unfortunately, borophene only exists inside of an ultrahigh vacuum chamber, limiting its practical use outside the lab. By bonding borophene with atomic hydrogen, the Northwestern team created borophane, which has the same exciting properties as borophene and is stable outside of a vacuum.

The study marked the first time scientists have reported the synthesis of borophane. Although borophene is frequently compared to its super-material predecessor graphene, borophene is much more difficult to create.



"Materials synthesis is a bit like baking. Once you know the recipe, it's not hard to replicate. However, if your recipe is just a little off, then the final product can flop terribly. By sharing the optimal recipe for borophane with the world, we anticipate that its use will rapidly proliferate." MARK HERSAM Walter P. Murphy Professor of Materials Science and Engineering

SMALLEST-EVER HUMAN-MADE FLYING STRUCTURE

A new flying microchip—or "microflier"—developed at Northwestern has neither a motor nor an engine. Instead, it catches flight on the wind and spins like a helicopter through the air toward the ground.

By studying various types of wind-dispersed seeds, including those from maple trees, Professors John Rogers and Yonggang Huang optimized the microflier's aerodynamics to ensure that when dropped at a high elevation, it falls at a slow velocity in a controlled manner. This behavior stabilizes its flight, ensures dispersal of the microfliers over a broad area, and increases the amount of time microfliers interact with the air, making them ideal for monitoring air pollution and airborne disease.

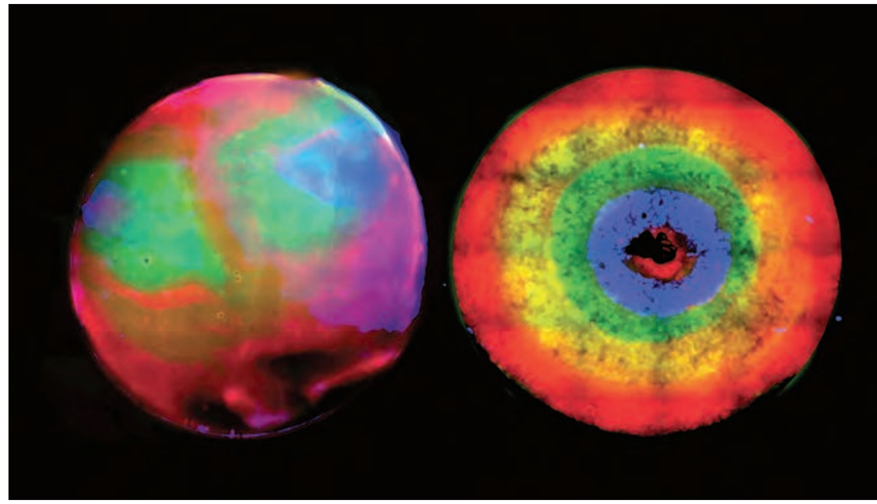
These microfliers also can be packed with ultraminiaturized technology, including sensors, power sources, antennas for wireless communication, and embedded memory to store data.

US FREIGHT RAILROADS BOLSTERED SUPPLY CHAIN RESILIENCE DURING PANDEMIC

Even as other parts of the US supply chain faced disruptions and setbacks, the freight rail industry demonstrated resilience and reliability during the COVID-19 pandemic, according to a report by the Northwestern University Transportation Center.

Despite the particularly volatile period, railroads met the unexpected surge in consumer and business demand, reliably delivering goods such as agricultural products, personal protective equipment, and retail merchandise, much of it ordered online. The industry's performance underscores rail's role as an essential component of the US economy.

Available online, the report was prepared by Northwestern Engineering transportation and infrastructure experts Joseph Schofer, Hani Mahmassani, Max Ng, and Breton Johnson.



"WALKING" MOLECULES COULD AID REGENERATIVE MEDICINE

Their discovery of a new printable biomaterial that can mimic properties of brain tissue moves Professor Samuel I. Stupp and Northwestern Engineering researchers closer to developing a platform capable of treating degenerative diseases or brain and spinal cord injuries using regenerative medicine.

Key to the discovery is the ability to control the self-assembly processes of molecules within the material, enabling the researchers to modify the structure and functions of the systems from the nanoscale to the scale of visible features. Published in the journal *Science* in 2018, Stupp's laboratory paper showed that materials can be designed with highly dynamic molecules programmed to migrate over long distances and self-organize to form larger, "superstructured" bundles of nanofibers.

Now, a research group led by Stupp has demonstrated that these superstructures can enhance neuron growth, a finding that could have important implications for cell transplantation strategies for neurodegenerative diseases, such as Parkinson's and Alzheimer's, as well as spinal cord injury.

"This is the first example where we've been able to take the phenomenon of molecular reshuffling we reported in 2018 and harness it for an application in regenerative medicine. We can use constructs of the new biomaterial to help discover therapies and understand pathologies."

SAMUEL I. STUPP Director, Simpson Querrey Institute

COVID-19 PCR TESTS CAN BE FREEZE-DRIED

Professor Michael Jewett and fellow researchers discovered that commercially available polymerase chain reaction tests can withstand the freeze-drying process, making them shelf-stable for up to 30 days at up to 50 degrees Celsius (122 degrees Fahrenheit) without sacrificing sensitivity and accuracy. The researchers found that the testing reagents could be premixed with a standard preservative, freeze-dried, and then distributed and stored at room temperatures. When the test is needed, healthcare workers add water to rehydrate the test for immediate use. The new strategy could help ease logistical challenges, making tests more widely available.

MATERIALS SCIENTISTS TO EXAMINE MYSTERIOUS COPPER ARTWORKS

Northwestern materials scientists will examine eight Bolivian copper artworks from the Carl & Marilynn Thoma Foundation to help piece together the works' unknown origins.

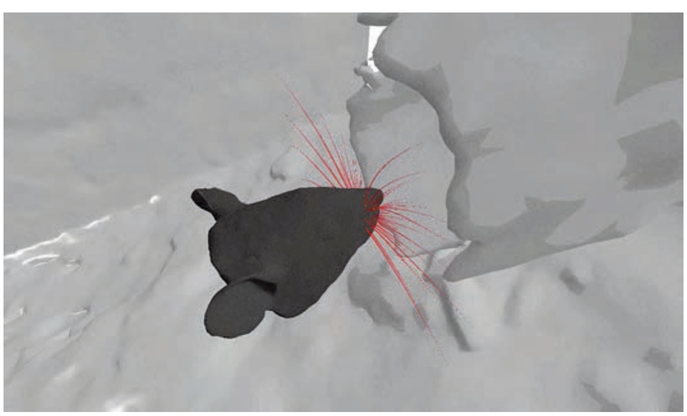
The Center for Scientific Studies in the Arts—a joint venture of Northwestern University and the Art Institute of Chicago—selected the Thoma Foundation's works for scientific analysis, with potential to provide insights into the artworks' origins and the materials and techniques used in their creation.

The Thoma Foundation collections contain more than 175 works from the Spanish Americas. Among them are eight oil paintings on embossed, chased, and engraved copper thought to have originated in the La Paz region of Bolivia. These artworks, made in workshop settings and produced at large scale for export across the South American continent from the seventeenth to the nineteenth century, are not well understood and have received scant scholarly attention.

The partnership will use advanced imaging techniques, extensive analytical resources, and technical expertise in their investigation.

"WE AIM TO BE A PART OF THE DIALOGUE THAT RECENTERS THE NEW WORLD TO RECOGNIZE IT AS A LOCALE OF CULTURAL RICHNESS, DEEP INDIGENOUS KNOW-HOW, AND IMPORTANCE."

MARC WALTON Research Professor of Materials Science and Engineering; Co-director, Center for Scientific Studies in the Arts



FIRST 3D SIMULATION OF RAT'S COMPLETE WHISKER SYSTEM

Researchers led by Professor Mitra Hartmann have developed the first full, three-dimensional, dynamic simulation of a rat's complete whisker system, offering rare, realistic insight into how rats obtain tactile information. Called WHISKiT, the new model incorporates 60 individual whiskers, each anatomically, spatially, and geometrically correct. The technology could help researchers predict how whiskers activate different sensory cells to influence which signals are sent to the brain and thus provide new insights into the mysterious nature of human touch.

With just a brush of their whiskers, rats can extract detailed information from their environments, including an object's distance, orientation, shape, and texture. This ability makes the rat's sensory system ideal for studying the relationship between mechanics (the moving whisker) and sensory input (touch signals sent to the brain).

2

Catalysts with nanoscale proximity engineered by Justin Notestein to more efficiently produce propylene

36

Percent fewer non-COVID-19-related research projects initiated in 2020 compared to 2019, according to study from Dashun Wang

Implanted Device Triggers Mice to Form Instant Bond

Professors John Rogers and Yonggang Huang and neurobiologists wirelessly programmed—and then deprogrammed—mice to interact socially with one another in real time using a first-of-its-kind ultra-miniature, wireless, battery-free, and fully implantable device that uses light to activate neurons. The study is the first to use optogenetics—a method for controlling neurons with light—to explore social interactions within groups of animals, impossible with current technologies.

Novel System Improves AI Testing

Though artificial intelligence (AI) can answer questions with clear-cut answers, it lacks the day-to-day common sense human beings need to move through complex life decisions.

Work by Professor Douglas Downey might have inched closer to bridging that gap by developing a new system for automatically writing and testing large sets of questions to assess an AI system's common sense.

Their method, called Generative Data Augmentation for Commonsense Reasoning (G-DAUG^c), generates additional training data for "commonsense" models and improves accuracy without requiring more annotations.

G-DAUG^c is available online, and visitors to the website can view training examples produced for a commonsense dataset called WinoGrande, where the goal is to choose the word that best fits in the blank. A usual approach to evaluating commonsense reasoning in language-processing systems is to test them on a large set of natural-language questions. Evaluations are based on how accurately the systems can answer the questions, and how many hand-authored training questions are required to achieve accuracy.

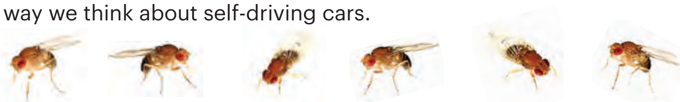
"While true commonsense reasoning with AI models is, we believe, still several years in the future, our results were able to improve current capabilities by 1 to 8 percent on four popular benchmarks."

DOUGLAS DOWNEY Professor of Computer Science

IS FRUIT FLY BEHAVIOR THE NEXT STEP TOWARD AUTONOMOUS VEHICLES?

The AAA annual survey on autonomous driving may send automakers back to the drawing board before rolling out fully autonomous self-driving systems. More than 70 percent of survey respondents said they would fear being in a fully self-driving car. But research from Professor William Kath shows that putting fruit flies instead of robots behind the wheel may be a better alternative.

That study published in the journal *Nature Communications* demonstrates that fruit flies use decision-making, learning, and memory to perform simple functions like escaping heat. Researchers are using this understanding to challenge the way we think about self-driving cars.



NEW MATERIAL CAPTURES AIRBORNE DROPLETS

To enhance the function of protective barriers, Professor Jiaxing Huang and his team have developed a new transparent material that can capture droplets and aerosols, effectively removing them from air.

The material is a clear, viscous liquid that can be painted onto any surface, including plastic, glass, wood, metal, stainless steel, concrete, and textiles. When droplets collide with the coated surface, they stick to it, get absorbed, and dry up. The coating also is compatible with antiviral and antimicrobial materials, so sanitizing agents, such as copper, could be added to the formula.

10

Times faster the cell-free production of three chemical products is after Michael Jewett integrated cellular engineering with cell-free biosynthesis

5

Minutes or less needed for a COVID-19 test result with Vinayak Dravid's new nanomechanical testing platform

A "Swiss Army Knife" Solution for Water Pollution

Inspired by Chicago's many nearby bodies of water, a team led by Professor Vinayak Dravid developed a way to repeatedly remove and reuse phosphate from polluted waters. Researchers liken the development to a "Swiss Army knife" for pollution remediation as they tailor their membrane to absorb and later release other pollutants.

The team's Phosphate Elimination and Recovery Lightweight (PEARL) membrane is a porous, flexible substrate that selectively sequesters up to 99 percent of phosphate ions from polluted water. The membrane can be tuned by controlling the pH either to absorb or release nutrients to allow for phosphate recovery and reuse of the membrane for many cycles.


Josiah Hester


Linda Broadbelt


Alessandro Rotta Loria


Kornel Ehmann


John Rogers


Marcelo Worsley


Chad Mirkin


Jorge Nocedal


Eleanor O'Rourke


Wei Chen


Guillermo Ameer


Erica Hartmann

Faculty Awards

Josiah Hester Named 2021 Most Promising Engineer or Scientist by AISES

The award from the American Indian Science and Engineering Society recognizes outstanding American Indian and Alaska Native early career professionals in STEM disciplines.

Kornel Ehmann Awarded SME's Taylor Medal

The Taylor Medal is the highest honor given by SME to a researcher in the broad manufacturing field.

Chad Mirkin Wins Prestigious Royal Society of Chemistry Prize

Mirkin won the prize for contributions to supramolecular chemistry and nanoscience, in particular the invention and development of methods for nanolithography, high-area rapid printing, and photocontrol in nanoparticle synthesis.

Wei Chen Honored with Charles Russ Richards Memorial Award

A joint award from the American Society of Mechanical Engineers and Pi Tau Sigma National Mechanical Engineering Honor Society, the award recognizes one individual each year for demonstrating outstanding achievement in mechanical engineering.

Linda Broadbelt Elected to American Academy of Arts and Sciences

The AAAS is one of the nation's oldest and most prestigious honorary societies.

John Rogers Named Guggenheim Fellow

Rogers will use the fellowship to continue developing wireless, bioresorbable stimulators as bioelectronic medicine.

Jorge Nocedal Selected for Lagrange Prize

The Lagrange Prize in Continuous Optimization is awarded every three years for an outstanding contribution in the area of continuous optimization.

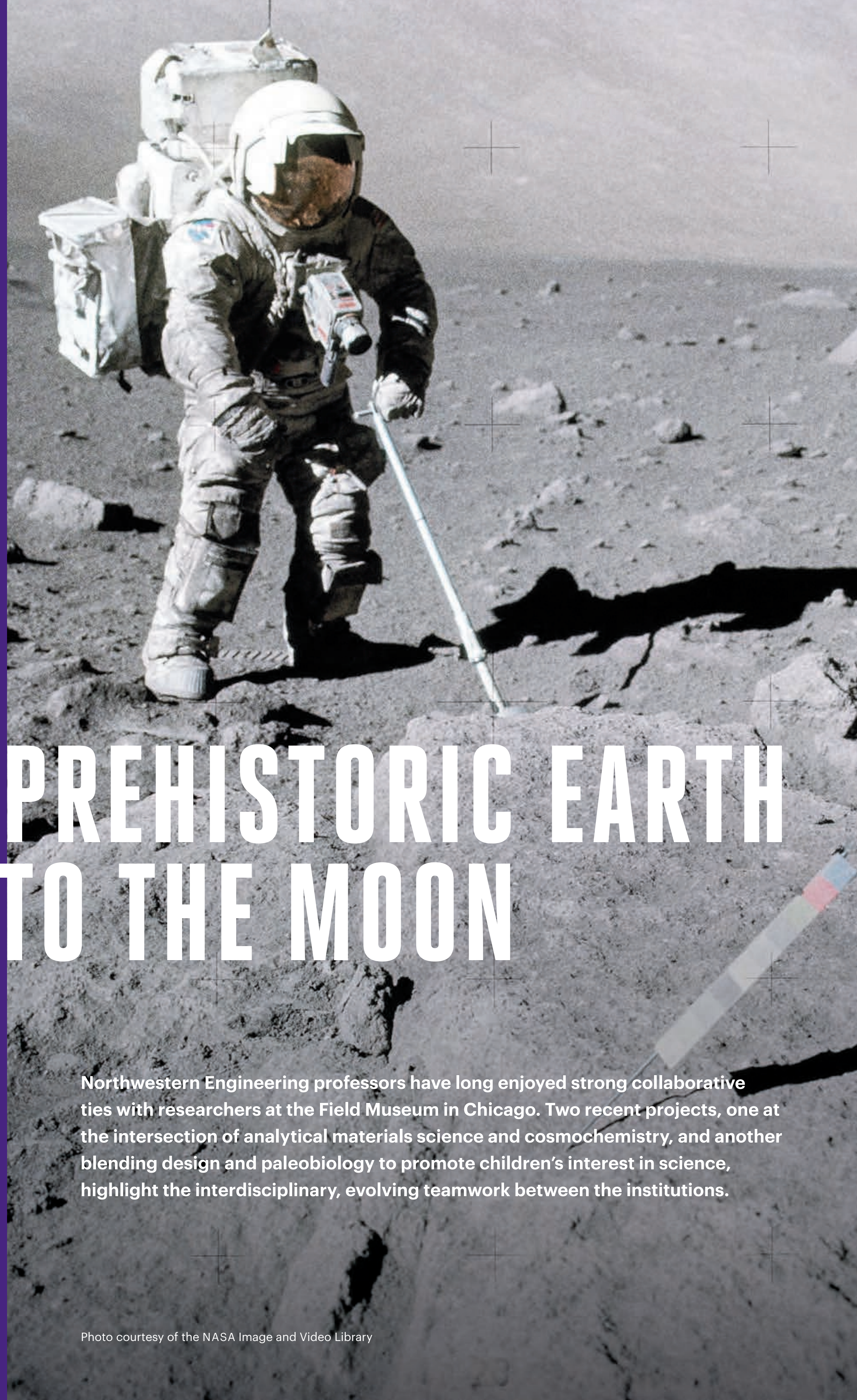
Guillermo Ameer Named Fellow of Materials Research Society

The MRS Fellows program recognizes outstanding contributions to the field, including research, leadership, and service that have advanced the mission of the materials community worldwide.

Alessandro Rotta Loria, Marcelo Worsley, Eleanor O'Rourke, and Erica Hartmann Recognized with NSF CAREER Awards

The Faculty Early Career Development (CAREER) Program offers the National Science Foundation's most prestigious awards in support of early-career faculty who have the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization. The four Northwestern Engineering faculty recipients will each receive $500,000 over five years.

NORTHWESTERN ENGINEERING AND FIELD MUSEUM COLLABORATIONS



SPAN PREHISTORIC EARTH TO THE MOON

Northwestern Engineering professors have long enjoyed strong collaborative ties with researchers at the Field Museum in Chicago. Two recent projects, one at the intersection of analytical materials science and cosmochemistry, and another blending design and paleobiology to promote children's interest in science, highlight the interdisciplinary, evolving teamwork between the institutions.

Photo courtesy of the NASA Image and Video Library

AN UP-CLOSE LOOK AT FAR-OUT MATERIALS

In 1972, when NASA's Apollo 17 astronaut crew returned home from the space agency's final crewed mission to the Moon, they brought with them 250 pounds of rocks and soil from the lunar surface.

For nearly 50 years, scientists have had to balance preservation of this scarce resource with a natural curiosity to study the material in hopes of uncovering new insights about the Moon and our solar system.

When Philipp Heck, Robert A. Pritzker Curator for Meteoritics and Polar Studies and head of the Robert A. Pritzker Center at the Field Museum, and Jennika Greer, a resident graduate student at the Field Museum, gained access to a sample of lunar soil in 2019, they turned to Northwestern Engineering materials scientists David Seidman and Dieter Isheim to help them uncover its secrets.

To do so, the researchers needed only a single grain of the sample.

Using the LEAP 5000XS atom probe tomograph, the flagship instrument at the Northwestern University Center for Atom-Probe Tomography (NUCAPT), Seidman and Isheim visualized the lunar soil's atomic structure and determined the precise location and chemical identities of individual atoms within the grain. Normally used to study metals, semiconductors, and ceramics, the atom probe unleashed a pulsing ultraviolet laser onto the tiny lunar sample, releasing its atoms and providing data to record spatial locations in three dimensions.

"With the atom probe tomograph, we conduct chemical analyses by counting individual atoms. Our typical datasets may include tens of millions of atoms, but that's still a microscopic volume," says Seidman, Walter P. Murphy Professor of Materials Science and Engineering and director of NUCAPT. "We don't need much material to gain an understanding of the chemical composition of a sample, which is useful when the primary source, like lunar soil, is extremely finite."

In analyzing the speck of lunar dust under the atom probe, the researchers found evidence of space weathering, a phenomenon where exposure to solar and cosmic radiation induces chemical changes to the outer layer of the material. The ionized hydrogen atoms (protons) and trace amounts of helium detected, they confirmed, came from our sun. The analysis also found the presence of iron and water molecules that formed in the dust grains due to exposure to solar wind.

By pinpointing the differences between the chemical composition of lunar soil that has been exposed to space weathering and soil that has not, scientists may better understand the composition of other materials in our galaxy.

"This technology to study lunar soil wasn't available in 1972. We can answer so many more questions today with the same samples that were collected by the Apollo 17 crew," Heck says. "This work has not only reinforced the value of mission-return samples, but also how great a resource the atom probe has been for extra-terrestrial materials science research at the Field Museum and our ongoing work with Northwestern."

The lunar soil analysis is the latest collaboration between NUCAPT and the Field Museum, a partnership at the intersection of analytical materials science, planetary sciences, and cosmochemistry that dates back more than a decade. Supported by NASA, other collaborations have included analyzing presolar dust, nanodiamonds found within the Allende meteorite, and other meteoritic samples.

"Our collaborations have cascaded," says Isheim, research associate professor in materials science and engineering and NUCAPT manager. "With the technology to send probes to asteroids and comets ever improving, we're hopeful to explore even more samples in the future."

ALEX GERAGE

Photography by Sean Russell, Field Museum

ATOM PROBE TRAVELS TO THE FIELD

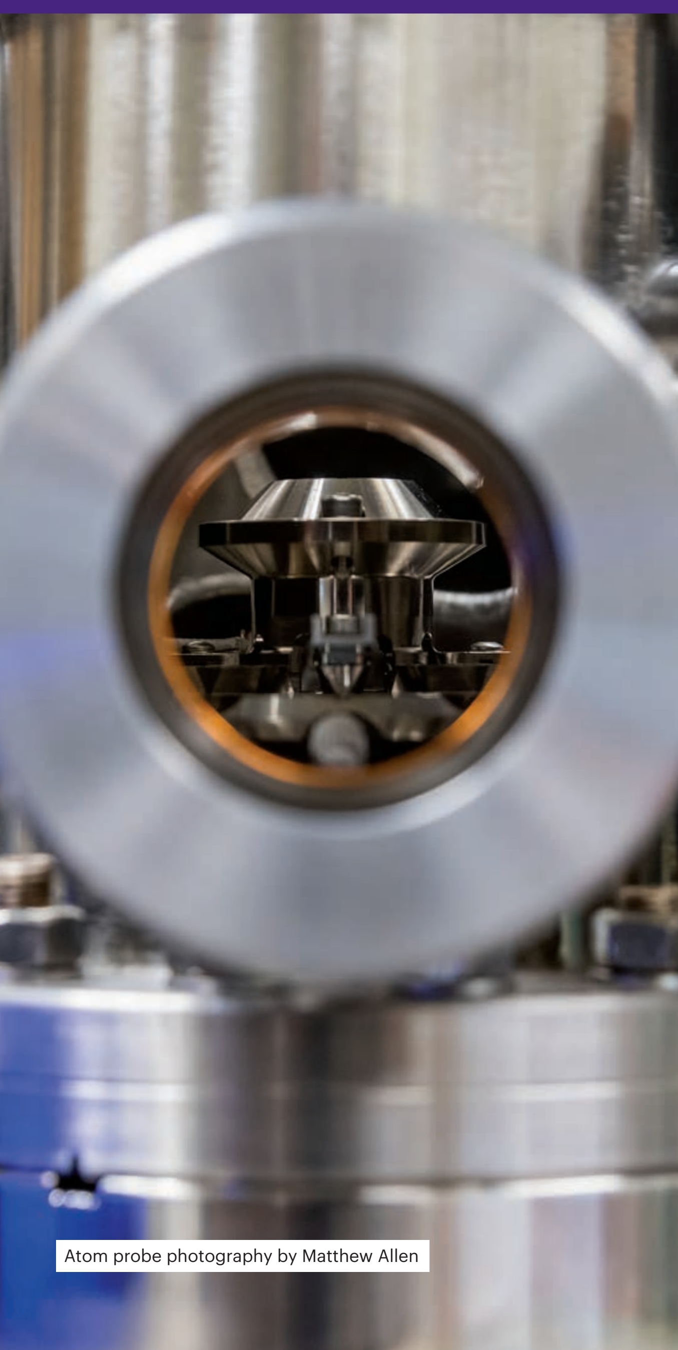
On display at the Field Museum's Searle Family Lounge through March 2022, the VG FIM 100 atom probe field ion microscope offers museum guests an up-close look at a device that first allowed researchers to see materials at an atomic scale.

This atom probe is the precursor to the LEAP 5000XS tomograph, the model currently used at the Northwestern University Center for Atom-Probe Tomography. Gregory Olson, a pioneer in computational materials design and Walter P. Murphy Professor Emeritus of Materials Science and Engineering, brought the device from the Massachusetts Institute of Technology after he joined the Northwestern faculty in 1988.

In 2004, Northwestern donated the VG FIM 100 atom probe to the Museum of Science and Industry. Before the atom probe arrived on loan at the Field Museum, it had been exhibited at MSI's *Materials Science* exhibit as well as at O'Hare International Airport and the Harold Washington Library Center.

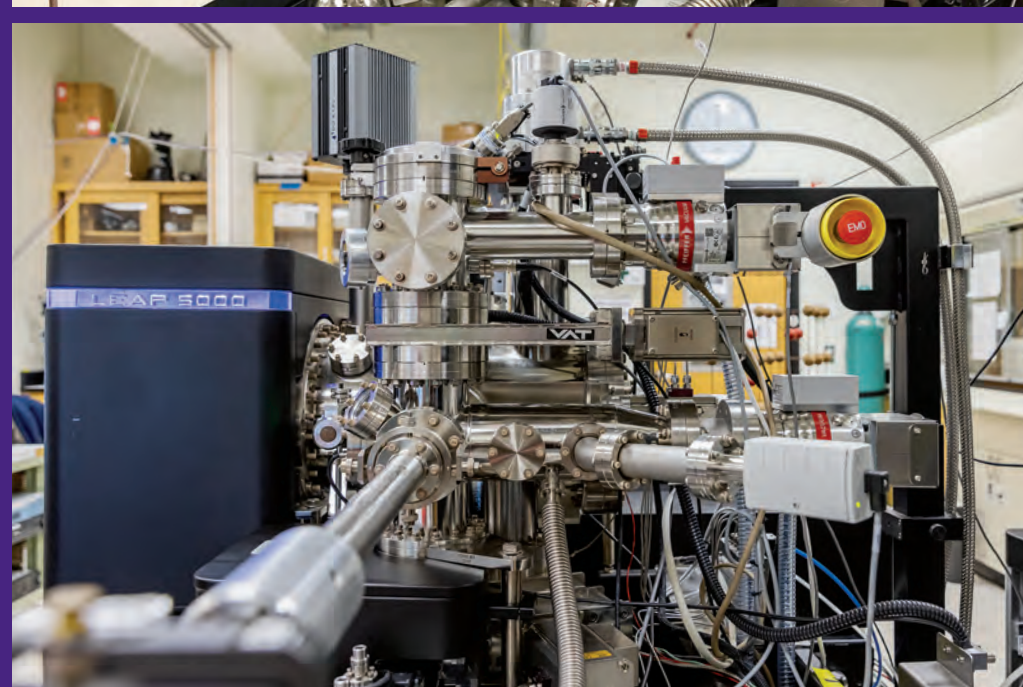
"THIS WORK HAS NOT ONLY REINFORCED THE VALUE OF MISSION-RETURN SAMPLES, BUT ALSO HOW GREAT A RESOURCE THE ATOM PROBE HAS BEEN FOR EXTRATERRESTRIAL MATERIALS SCIENCE RESEARCH AT THE FIELD MUSEUM AND OUR ONGOING WORK WITH NORTHWESTERN."

PHILIPP HECK Robert A. Pritzker Curator for Meteoritics and Polar Studies and Head of the Robert. A. Pritzker Center at the Field Museum



Atom probe photography by Matthew Allen

Jennika Greer operates the atom probe tomograph. Photography by Dieter Isheim



"OUR GOAL IN DEVELOPING FOSSIL CANYON WAS TO CREATE AN ENJOYABLE FAMILY EXPERIENCE WHILE ALLOWING CHILDREN TO ENGAGE CREATIVELY WITH PALEOBIOLOGY."

KEVIN LYNCH Professor of Mechanical Engineering and Director of the Center for Robotics and Biosystems

MAKING A GAME OF PALEOBIOLOGY

After watching his then kindergarten-age children adapt to—and at times struggle with—the challenges of remote learning brought on by the COVID-19 pandemic, the McCormick School of Engineering's Kevin Lynch and his wife, Yuko, felt inspired to help them better understand their science lessons, which included a curriculum on dinosaurs.

Working with graphic designer Nathan Martel and Akiko Shinya, chief preparator of fossil vertebrates at the Field Museum, the Lynches created Fossil Canyon, a card game where players collect dinosaur fossils to display in their own museums. The colorful cards reveal information about specific dinosaurs, including pronunciations and timeframes of when the creatures roamed the planet, and enable families to have fun and learn together. A companion booklet outlines the basics of paleontology.

"Our goal in developing Fossil Canyon was to create an enjoyable family experience while allowing children to engage creatively with paleobiology," says Kevin Lynch, professor of mechanical engineering and director of the Center for Robotics and Biosystems. "Paleobiology is not robotics, my specialty, but anything that gets kids, including my own, excited about science works for me."

As the project's science adviser, Shinya ensures the game's scientific accuracy and also interfaces with leadership at the Field Museum, a partner in the project. "Kevin's passion for education was inspiring and I was impressed with his creativity and dedication," Shinya says. "Fossil Canyon is packed with science and much more educational than a simple card game. I was thrilled that I could advise on its scientific contents."

Polymath Play, the parent company for Fossil Canyon, successfully funded the production of 2,000 copies of the game with a Kickstarter campaign in the summer of 2021. Fossil Canyon might eventually be sold in Field Museum gift shops.

"The Field Museum excels in scientific research and outreach to the public. It was exciting to have an opportunity to work with them, and Akiko specifically, on this unique science outreach project," Kevin Lynch says. "They are pros at science communication, and science communication is an important part of what we do. It's been both fun and educational."

ALEX GERAGE AND BRIAN SANDALOW

COLLABORATIONS SPAN DISCIPLINES

Combining unique domain expertise with innovative research technology and methodologies, scientists from Northwestern Engineering and the Field Museum have shown that collaboration happens best at the intersection of disciplines. Other collaborations between the two have included:

Understanding Coral Bleaching

Warmer ocean waters caused by climate change have jeopardized the long-term health of coral reefs. Luisa Marcelino, research assistant professor of civil and environmental engineering and a scientific affiliate at the Field Museum, along with Vadim Backman, Sachs Family Professor of Biomedical Engineering and Medicine, worked with Field Museum biologists to study why some species of coral are more susceptible than others to coral bleaching, a phenomenon that occurs when changes in environmental conditions cause coral to expel their life-giving algae. Using Backman's optical imaging technology originally designed for early cancer detection, the researchers discovered that corals that are less efficient at scattering light to nearby symbiotic algae—a food source for the corals—are more likely to survive when stressed.

Optimizing Digital Displays for Natural History Exhibits

How can museums give visitors a greater appreciation of artifacts they can't touch or manipulate? That's the question Michael Horn, associate professor of computer science and of education and social policy at Northwestern, and Matt Matcuk, exhibitions development director at the Field Museum, set out to answer. Using cognitive curiosity models, the two tested three designs of an interactive sign display within the museum's Cyrus Tang Hall of China exhibit. Measuring visitor curiosity, interest, and engagement with the signage, they found that presenting bold questions on interactive display screens can help draw visitors in, while more visually engaging displays help promote user interaction.

BIOMATERIAL TECHNOLOGY MOVES FROM LAB BENCH TO THE ORTHOPEDIC MARKET

Resorbable anti-inflammatory tendon fixation technology used in patients for the first time

"Even though 20 years seems like a long time to see our technology get to

Northwestern biomedical engineer Guillermo A. Ameer has achieved a rare, major accomplishment: A medical product based on novel biomaterials pioneered in his laboratory will be widely available for use in musculoskeletal surgeries to directly benefit patients.

The biomaterial technology, called CITREGEN, developed by the startup company Acuitive Technologies Inc., is featured in Stryker Corporation's CITRELOCK, an innovative device that debuted in September. The CITRELOCK Tendon Fixation Device System is used to attach soft tissue grafts to bone in reconstructive surgeries and provides surgeons a differentiated design due to Ameer's biomaterial.

CITREGEN has unique chemical and mechanical properties for orthopedic surgical applications that help grafted tissue heal. It contains organic molecules and includes citrate, phosphate, and calcium, components that are essential to healthy bone growth. CITREGEN is the first thermoset biodegradable synthetic polymer ever used in implantable medical devices.

CITRELOCK, which received clearance from the US Food and Drug Administration last year, has a compressive strength comparable to cortical bone and maintains structural integrity during the healing phase, while allowing the implant to be remodeled by host tissue over time.

TWO DECADES OF TECHNOLOGY DEVELOPMENT

Ameer, Daniel Hale Williams Professor of Biomedical Engineering and professor of surgery in the Feinberg School of Medicine, who is also founding director of the Center for Advanced Regenerative Engineering (CARE), is on a mission to use engineering and workforce training to enable the practice of regenerative medicine to improve the outcome of surgeries and benefit patients.

"When I first started my lab years ago here at Northwestern, one of my major goals was to use engineering to have a positive impact on patient care. That goal has been a guiding principle for my research. I sought to work with surgeons to fully understand medical problems, patient needs, and constraints, and come up with solutions," says Ameer, who was recently elected to the National Academy of Medicine, one of the highest honors in the field.

"We first developed our citrate-based polymers 18 or so years ago and initially researched applications in vascular and orthopedic tissue engineering. For the latter, we created composites that are a mixture of the polymer and a ceramic, the foundation for CITREGEN. The first publication of those composites for bone regeneration, in collaboration with orthopedic surgeon Jason Koh, was in the journal *Biomaterials* in 2006. Our work has been expanded upon by other researchers around the world, perhaps most notably by my former postdoctoral trainee Jian Yang, now Dorothy Foehr Huck and J. Lloyd Huck Chair in Regenerative Engineering at Pennsylvania State University.

market, we are fortunate to achieve this milestone in my academic career."

"A decade later, through collaborations with industry, we were able to jump-start the translation process to use our polymer technology in innovative bioresorbable orthopedic devices. Even though 20 years seems like a long time to see our technology get to market, we are fortunate to achieve this milestone in my academic career."

On searching for new materials: "What drove the development of citrate-based polymers and composites was the need to work with materials that were elastic like rubber, easy to tailor, and could support cell functions, but also would safely dissolve away in the body while being replaced with normal tissue—as no such material existed at the time. Working with an excellent team of students and postdocs, we invented a material by taking into account a variety of requirements from the start. These included the body's mechanism for degradation, ability to synthesize easily and with safe components, and modularity to control material properties for a variety of potential applications. Throughout the years, we and others have demonstrated that citrate-based polymer can be engineered into devices that help regenerate blood vessels, skin, heart, cartilage, bone, bladder, and muscle tissues."

On demand for better devices: "There is a demand from surgeons and patients for better bioresorbable devices, ones that promote tissue regeneration or at least would not interfere with it. It is not easy to introduce new devices built with new bioresorbable polymers in the market due to problems with implants made from traditional biodegradable polymers and the scrutiny from regulatory agencies when reviewing new bioresorbable devices. It was a long process but well worth it to bring new solutions to the market through established medical device companies."

On taking risks: "Although we pioneered and have been working on this biomaterial technology for almost 20 years, significant credit goes to visionary individuals from industry, specifically from Acuitive Technologies and Stryker, for recognizing the potential of our technology and investing resources for its development and validation. It took Acuitive six years to develop CITREGEN into useful products. The collaborations and partnerships that CARE has formed are important to replicating CITREGEN's success in other health applications and translating into clinical practice other types of regenerative engineering technologies in the future."

WIN REYNOLDS

Photograph of Guillermo A. Ameer by Chris Strong
Device Images by Acuitive Technologies


16
SKF

BUILDING COMMUNITY. MAKING AN IMPACT.

Student groups foster exciting experiences, innovative thinking, and lasting memories beyond the classroom.

"WE WANT TO MAKE SURE STUDENTS DEVELOP THEIR OWN LEADERSHIP STYLES AND PARTNER WITH THE SCHOOL AND OTHER STUDENT GROUPS TO HELP EVERYONE GROW AND LEARN TOGETHER."

ELLEN WORSDALL Assistant Dean for Student Affairs

Forging relationships and friendships that last a lifetime is a vital part of the Northwestern Engineering experience. Many undergraduate students form these essential connections in student groups.

"When alumni come back for events, they always remember the projects and competitions they had in their student groups," says Ellen Worsdall, assistant dean for student affairs. "Those stories live long in their memories after they graduate."

For more than 20 years, Worsdall has worked with McCormick School of Engineering departmental, design, special interest, and honors student groups. As assistant dean, she gives student groups support and structure, organizing programming to strengthen leadership skills, helping them identify organizational goals, and working with them to establish professional networks with industry partners.

"We want to make sure students develop their own leadership styles and partner with the school and other student groups to help everyone grow and learn together," she says.

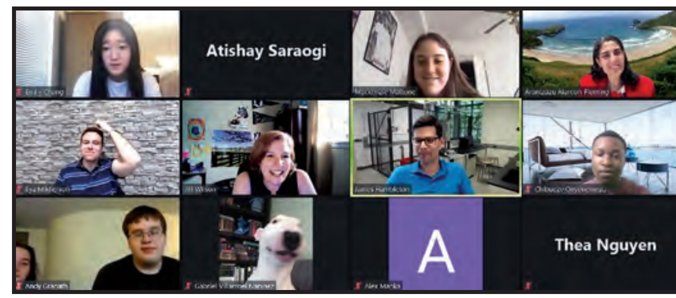
Worsdall's work setting up these groups for success has a far reach: about half of engineering students take part in one or more of the 29 engineering school groups or the dozens of other student groups across Northwestern.

That means outside of the classroom, students have a multitude of options to learn how to work in teams and apply lessons learned to real-world situations. Groups also help students gain useful experience while figuring out what they want to do professionally. Club projects offer a chance to develop problem-solving, leadership, time-management, budgeting, and networking skills.

For most students, relationship building is the best part of joining a student group, Worsdall says. In addition to friendships, students develop mentoring relationships with older students and those pursuing different majors.

"The energy students bring to groups is exciting," says Worsdall, adding, "There are always new ideas—it's never the same day twice."

Here are just a few of the student groups working to make an impact, both inside and outside Northwestern.



McCormick Student Advisory Board

When the COVID-19 pandemic hit and access to campus was restricted, most student groups had to reassess their projects and evaluate what was possible under the circumstances. The McCormick Student Advisory Board (MSAB), a diverse group that serves as representatives for the Northwestern Engineering student body, and its president Jacob Rogers (industrial engineering '22), jumped into action.

"During the pandemic, we hosted quarterly workshops and check-ins for student groups," Rogers says. "Seeing how creative everyone has been and sharing ideas for getting members engaged and recruiting new members in a fully virtual environment was very interesting."

To help foster connections last year, MSAB matched more than 200 students into pairs or small groups based on survey responses about shared interests and lifestyle habits. They created a list of virtual activities and offered prizes for groups that were able to get to know one another. This year, they hope to transition these activities to in-person events to help students develop friendships and navigate campus.

Every time MSAB meets, Rogers is impressed by the creativity of his fellow board members. "They have such a strong desire to drive change at McCormick," he says. "The ideas they throw around are really remarkable."

Engineers for a Sustainable World

Engineers for a Sustainable World (ESW) offers a place where students can find resources they need to turn sustainable ideas into reality. The Northwestern chapter of this global organization builds leaders in sustainability through education and commitment to action-oriented projects.

The unique structure of the chapter allows subgroups to work under the ESW umbrella, says Bill Yen (mechanical engineering ’23), co-president. The oldest active subgroup, SmartTree, is building Northwestern’s first mobile, solar-powered charging station to provide more outdoor workplaces and renewable energy installations on campus.

Another subgroup, AutoAquaponics, is creating a fully automated, remotely-monitored and controlled farming system that will efficiently grow fish and plants without human labor for at least one month, while minimizing the use of water and electricity. The project grew out of necessity when COVID-19 restrictions prohibited members from maintaining the club’s manual hydroponic system, Yen says. The team hopes to pilot the new remote system during winter or spring quarter.

“With a lot of the projects we’re working on, we’re not just trying to replicate what’s already been done; we’re building things that don’t exist right now,” he says. “I hope the innovations we’re driving will make their way outside Northwestern and contribute to our fight against climate change.”

"I HOPE THE INNOVATIONS WE'RE DRIVING WILL MAKE THEIR WAY OUTSIDE NORTHWESTERN AND CONTRIBUTE TO OUR FIGHT AGAINST CLIMATE CHANGE."

BILL YEN
Mechanical Engineering ’23, Engineers for a Sustainable World

Northwestern Solar Car Team

“We build a car that, at certain speeds and powered by the sun, can drive forever." That’s how Zachary Martin (materials engineering ’22) describes NUsolar—the Northwestern University Solar Car Team—where student members design, manufacture, and race fully electric, solar-powered vehicles.

Advancing sustainable transportation technology is NUsolar’s goal, but the pandemic threw a wrench in the group’s plans, forcing it to postpone competing. Now that the group is able to meet in person again, Martin hopes to finish manufacturing by March. “We’re looking forward to a really exciting year of building and racing again come July.”

The group also anticipates returning to outreach events, where they show their car to the community to demonstrate what’s possible with sustainable energy, Martin says. “We hope to get out there and help the transition to a sustainable future.”

"WE WANT TO BE MORE CONSCIOUS OF OUR CONTRIBUTION TO THE UNIVERSITY'S VISION FOR SUSTAINABILITY."

BRIAN HONG
Economics and Data Science '23, Northwestern Formula Racing

"I'VE HAD THE PRIVILEGE OF MEETING SO MANY WONDERFUL, SMART, AND EMPOWERING WOMEN THROUGH WiC."

MEGHA RAMANATHAN
Computer Science '22,
Women in Computing

Women in Computing

Megha Ramanathan (computer science '22) wanted to join Women in Computing (WiC) before she even arrived on campus. Her older sister, Tara Ramanathan (WCAS '20), was a member and spoke highly of the WiC community. "Joining was one of my best decisions," Megha says. "I've had the privilege of meeting so many wonderful, smart, and empowering women through WiC."

Today, Megha and Megan Yaur (computer science '22) serve as co-presidents of the group, a community of female, non-binary, and trans students who are passionate about technology. WiC connects members with mentors and helps them develop technical and interpersonal skills through workshops and leadership opportunities. Events include tech talks, hack nights, interview prep (with industry experts from Google and Facebook), and participation in the Grace Hopper Celebration, a series of conferences offering career and learning opportunities to women in computing.

Outreach is also a major part of the group's mission. WiC partners with Chicago Public Schools to introduce girls to coding. At Northwestern Engineering's Career Day for Girls, group members taught eighth graders how to code using HTML and CSS. "I remember hearing one girl say, 'This is so fun. I'm going to keep doing this at home,'" Yaur says.

The group is optimistic that they'll be able to hold similar in-person events soon. "Students are eager to meet new people," Yaur says. "I bet this year we'll have an all-time record number of students who participate in student groups."

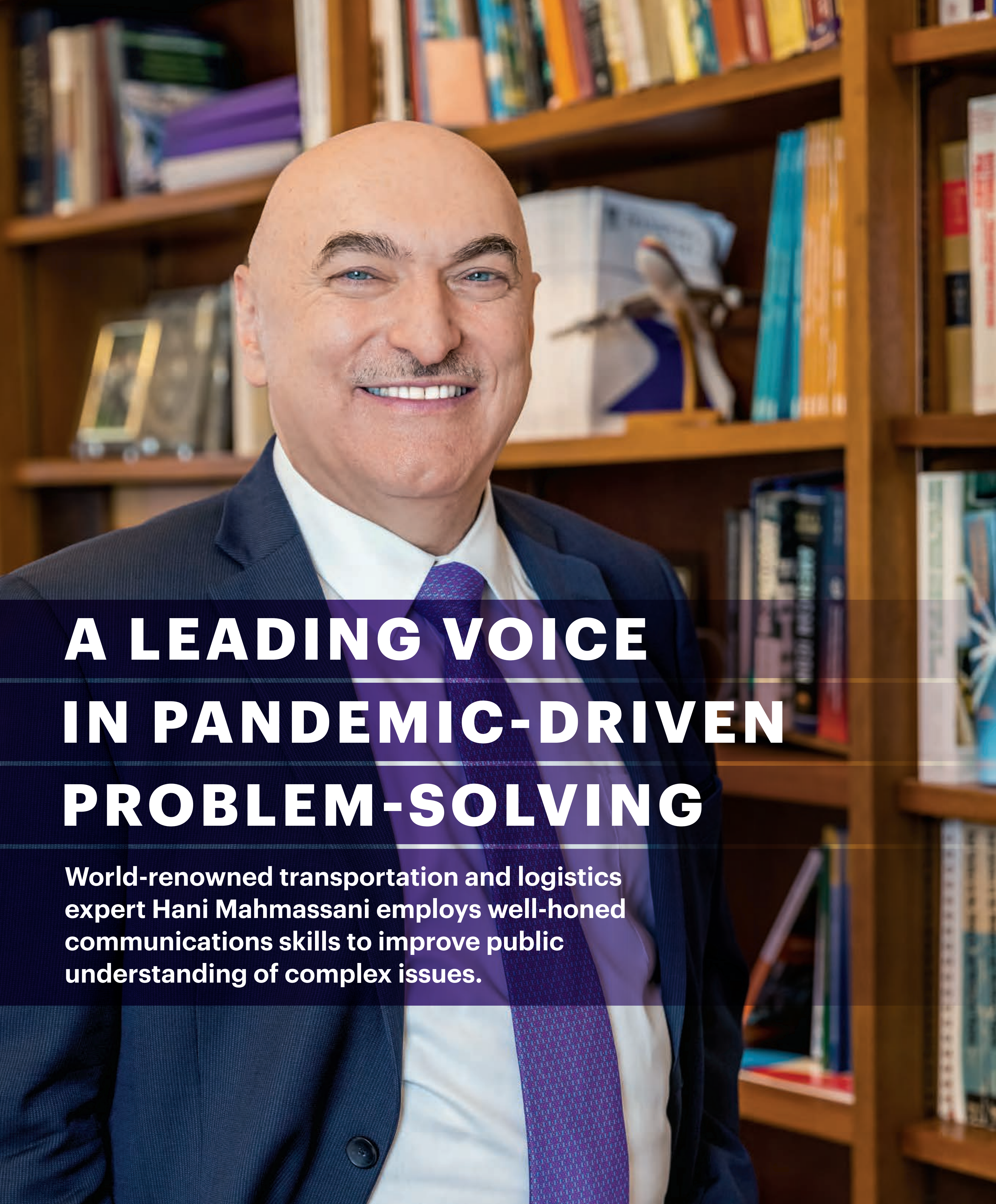
Northwestern Formula Racing

Northwestern Formula Racing gives students experience building, testing, and racing a car. Part of Formula SAE, an intercollegiate engineering design competition organized by SAE International (formerly the Society of Automotive Engineers), the Northwestern team builds one Formula-style internal combustion engine vehicle every academic year.

However, this year will be pivotal for team members as they embark on a two-year design cycle for their first electric vehicle, in addition to their annual internal combustion project. "We want to be more conscious of our contribution to the University's vision for sustainability," says project manager Brian Hong (economics and data science '23), referring to the decision to go electric. "We're also working to ensure the long-term success of the team."

Being part of this passionate team is what Sarah Yung (mechanical engineering '24), aerodynamics team lead, enjoys most about the group. "I can wander up to anybody in the autobay and learn all about their project or share what I'm doing with somebody who's excited to learn," she says. "It's so much fun hanging out with Formula friends late at night, when we're the last ones in Ford [Motor Company Engineering Design Center]."

SARA LANGEN



A LEADING VOICE IN PANDEMIC-DRIVEN PROBLEM-SOLVING

World-renowned transportation and logistics expert Hani Mahmassani employs well-honed communications skills to improve public understanding of complex issues.

“WHILE IT’S AN ENGINEERING DISCIPLINE, ON A DAY-TO-DAY BASIS, TRANSPORTATION IS INTERTWINED WITH EVERYTHING WE HUMANS DO.”

HANI MAHMASSANI William A. Patterson Distinguished Chair in Transportation and Professor of Civil and Environmental Engineering

The COVID-19 pandemic triggered some of the greatest supply-chain challenges in recent history.

Hani Mahmassani, internationally known logistics expert, took on those challenges by doing what he does best—innovating and communicating.

Mahmassani, William A. Patterson Distinguished Chair in Transportation and professor of civil and environmental engineering at Northwestern Engineering, has spent the past 18-plus months working with industry on innovative ideas to move products efficiently, including COVID-19 vaccines, while exhibiting a knack for explaining it all in plain language to the public.

“Transportation is so closely tied to society, to our everyday life, in many ways,” says Mahmassani, who also serves as director of the Northwestern University Transportation Center (NUTC), a leading interdisciplinary education and research center serving industry, the government, and the public. “While it’s an engineering discipline, on a day-to-day basis, transportation is intertwined with everything we humans do.”

Strategic collaboration to meet demand

In early 2020, public panic spread quickly over the availability of soap and toilet paper, upending distribution patterns and spiking interest in supply chains. That prompted Mahmassani and NUTC’s Business Advisory Council (BAC) to convene nine weekly roundtables to look into the state of supply chains.

Through these events, BAC members—representing shipping, transportation, logistics, and other related industry sectors—helped formulate strategies to get needed products into the hands of consumers. By leveraging real-time data, suppliers could identify and anticipate problem areas, intensify communication with all actors along the supply chain, and engage in collaborative arrangements, even among competitors.

“Our center always has been at the vanguard of developments in terms of professional outreach as well as engagement, but that is especially true now,” says Mahmassani, who was elected to the National Academy of Engineering earlier this year.

Mahmassani and Karen Smilowitz, James N. and Margie M. Krebs Professor in Industrial Engineering and Management Sciences, also have launched a research initiative on how best to deploy COVID-19 vaccines.

They received a National Science Foundation Grant for Rapid Response Research (RAPID) to track vaccine distribution and tap the expertise of major shipping and transportation company leaders. The award will help them create interim guidance for the evolving vaccine deployment process while developing a robust logistics design for similarly extreme deployment issues that may arise in the future.

Communicating solutions to the public

Fluent in Arabic, French, and English, Mahmassani is also highly skilled at communicating complex ideas to the public. When the Suez Canal was blocked in March by a grounded container ship, international media outlets sought out Mahmassani for his expertise.

When lockdowns began in 2020, he explained in media appearances that supply chains were hit hard because there had been so little time to plan for the pandemic’s impact. He also noted later that industry and governments were better at rolling out the vaccines because they had more time to prepare.

Mahmassani sharpened his communication skills in the classroom, where he has taught students adaptability, resilience, and confidence in problem-solving. His teachings included remaining aware of one’s surroundings and addressing timely issues using the core knowledge and toolset that a Northwestern education provides.

“Hani is an important asset for Northwestern and for the field of transportation and logistics,” says Joseph Schofer, professor emeritus of civil and environmental engineering and an expert in transportation. “A big part of that is his ability to blend a broad skill set with a ton of enthusiasm.”

BRIAN SANDALOW

LAB TOUR
MULTI-SCALE 3D PRINTING INFRASTRUCTURE LABORATORY

Northwestern Engineering's labs are as diverse as the research and teaching performed in them. Here, we spotlight the Multi-scale 3D Printing Infrastructure Laboratory within the Department of Civil and Environmental Engineering.

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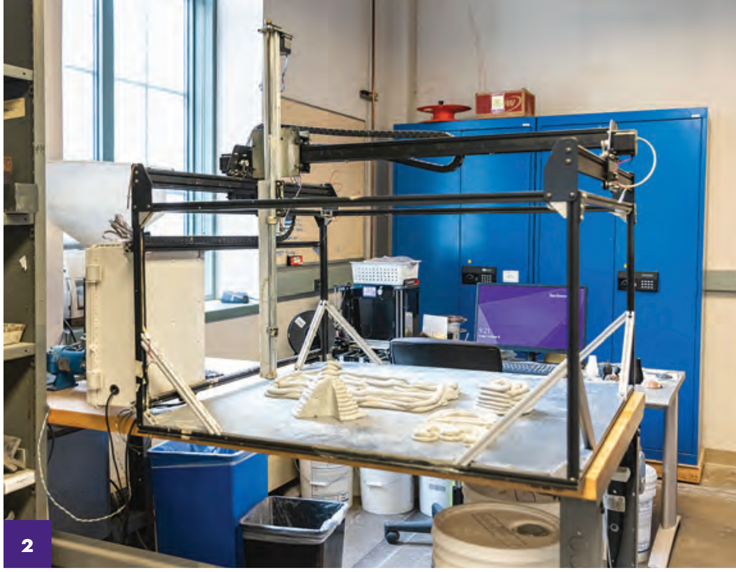

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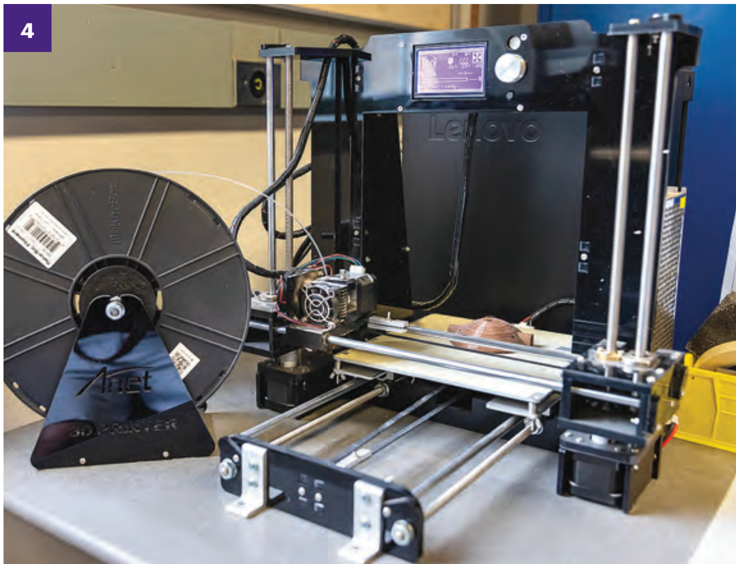

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With an eye toward developing more stable structures capable of withstanding harsh environmental conditions—including those that future astronauts will find on Mars—researchers in Northwestern Engineering's Multi-scale 3D Printing Infrastructure Laboratory seek to understand, simulate, and predict the mechanical behavior of quasi-brittle materials, such as concrete, timber, rocks, and composites.

"With a host of innovative technologies, we're formulating and validating novel models and computational tools to help future generations of engineers design more resilient and sustainable civil infrastructures," says Gianluca Cusatis, professor of civil and environmental engineering, who leads the lab.

Located in the Technological Institute's A wing, the 3,200-square-foot facility's capabilities include an impressive array of advanced 3D printing and testing technologies.

1. CONCRETE 3D PRINTER: The large-scale 3D printer features an ABB Robotics IRB 6700 series high-performance industrial robot within a 280-square-foot enclosure that provides atmospheric isolation. With six axes of rotation, the robot offers a large range of configurations and seamless transitions between points in space, allowing lab members to study samples—up to five meters in size—of mortar, sulfur concrete, and Marscrete, the group's self-designed building concrete composed entirely of materials found on Mars.

2. CEMENT 3D PRINTER: The custom-designed, midscale cement printer uses a compact progressive cavity pump to 3D-print structures with up to a one-square-meter footprint using cement, gypsum, and other cement-based materials. Used to study rheological behavior of materials in the context of 3D printing, the printer is controlled by micro-controllers and Repetier-Host, a highly flexible open-source software package.

3. MTS UNIVERSAL TESTING MACHINES: Three machines and a closed-loop hydraulic system test construction materials and assemblies under pseudostatic and dynamic loading, with respective capacities of 20,000, 220,000, and 1 million pounds.

4. PLASTICS 3D PRINTER: An Anet A6 plastics 3D printer provides a 20-centimeter-square print area for developing mock-ups and equipment parts from a variety of plastic filaments.

5. SPLIT HOPKINSON PRESSURE BAR/KOLSKY BAR: This equipment tests high-strain-rate properties of materials and imposes a dynamic load on material samples, similar to what the materials will experience in dynamic situations like blasts, impacts, or other high-energy events.

6. HOTPACK ENVIRONMENTAL CHAMBERS: Cast and printed samples are cured up to 100 percent humidity in this curing room, used to test strength or replicate performance under specific environmental conditions.

ALEX GERAGE

Photography by Matthew Allen


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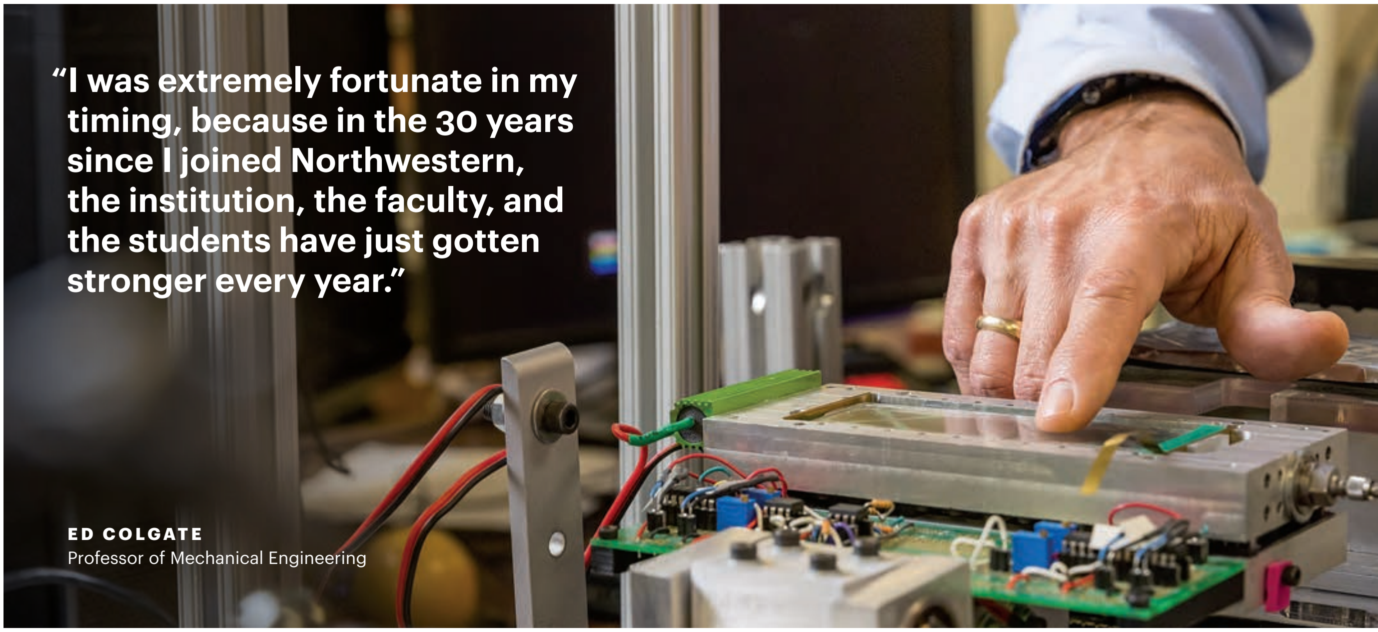
INSPIRED TOUCH

HUMAN-ROBOT INTERACTION EXPERT J. EDWARD COLGATE IS REVOLUTIONIZING THE TOUCHSCREEN EXPERIENCE



When Ed Colgate became interested in robotics as a graduate student in the 1980s, few could have imagined the lasting impact his work would have not only on human-robot interaction, but also on the thousands of individuals who have benefited from his life-changing innovations.

At the time, figuring out how to have a robot touch the world was a major challenge.

Simple jobs like spray-painting a car on an assembly line were possible. However, giving a robot a tool and asking it to put parts together or grind up metal was much more difficult. That's when Colgate began to look at the problem of robot interaction, first with the outside world and then as an intermediary between people and remote environments.

Today, the professor of mechanical engineering is a renowned leader in the field of human-robot interaction, particularly in haptic interfaces, cooperative robotics (cobots), remote manipulation, and advanced prosthetics. His pioneering work has earned numerous awards, including his recent election to the National Academy of Engineering, among the highest honors in the field.

SHAPING AN ENGINEERING COMMUNITY

Since he joined the Northwestern Engineering faculty in 1988, human-robot interaction has proven a rich vein of study for Colgate. He arrived just before the school received a $30 million grant from the Robert R. McCormick Foundation to rebuild the Technological Institute and develop new programs, ushering in an era of growth and change.

"I was extremely fortunate in my timing, because in the 30 years since I joined Northwestern, the institution, the faculty, and the students have just gotten stronger every year," he says.

It's a community Colgate has shaped in many ways, including helping to develop the Engineering First program, a visionary curriculum for first-year students that combines engineering analysis with design thinking and communication. He has provided mentorship and expertise as director of the Master of Science in Engineering Design Innovation degree program and founding co-director of the Segal Design Institute. His research also helped establish Northwestern's Center for Robotics and Biosystems.

Colgate collaborates on much of his work with mechanical engineering professor and Allen K. and Johnnie Cordell Breed Senior Professor of Design Michael Peshkin, with whom he shares a lab. Of their successful partnership, Peshkin says, "There's no one else I can so enjoyably and productively bounce ideas back and forth with. It's like we're on the same wavelength—we resonate."

CREATING RICHER HAPTIC INTERFACES

The duo's research has led to life-changing technologies, such as rehabilitation assistance for stroke survivors, interfaces for prosthetics, and haptics that help the blind interact with touch-screens. Tanvas, one of three successful companies they've launched, develops surface-haptic technology, which lets people feel what they see on a touchscreen.

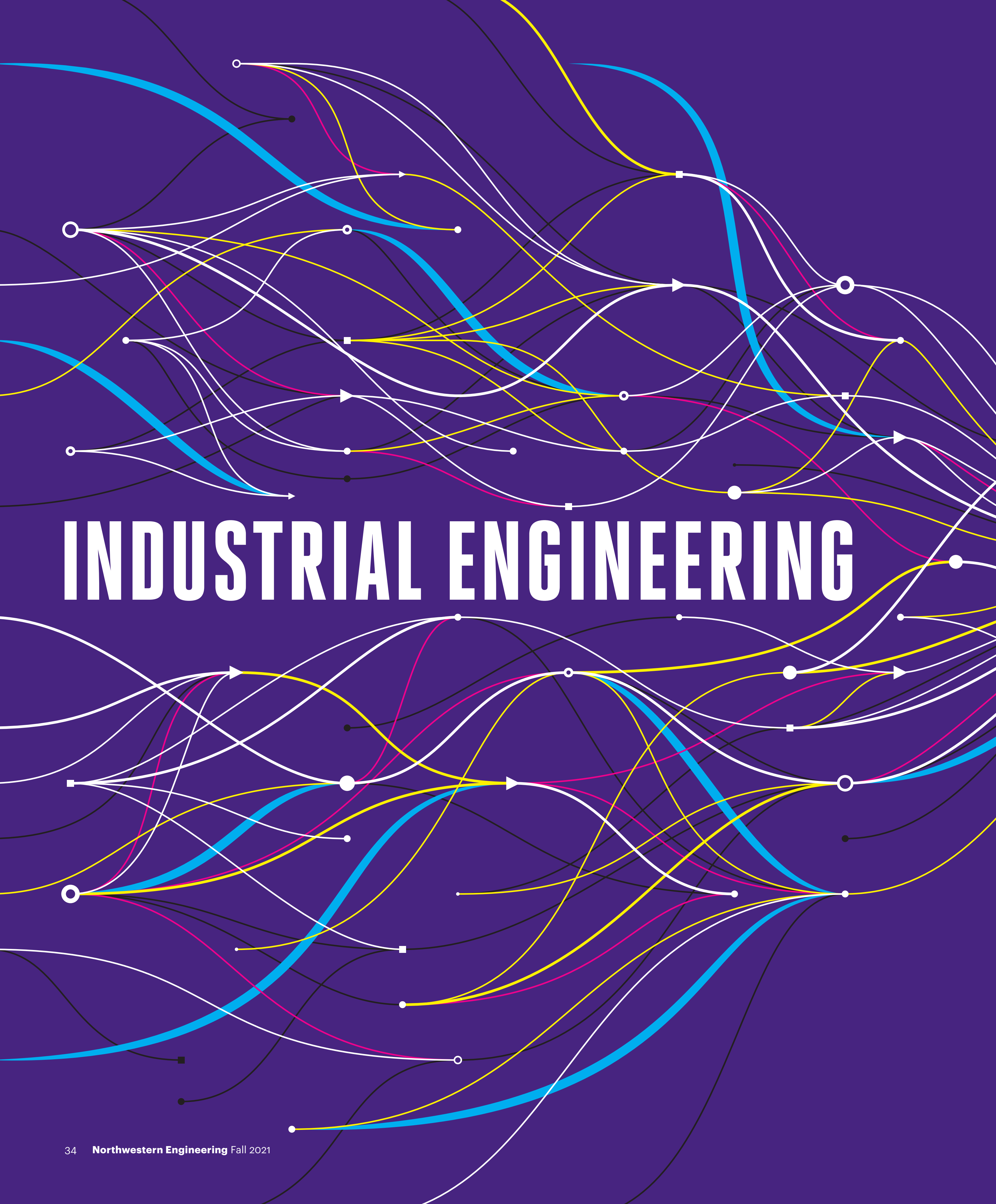
Colgate is committed to haptics, a field he advanced by founding the Haptics Symposium, the discipline's oldest conference. In the future, he hopes to build richer, fuller-featured haptic interfaces that can convey broader and more realistic sensations through touch and manipulation.

"I don't know exactly how far we'll get," Colgate says, "but I intend to give it a good go."

SARA LANGEN

Photography by Matthew Allen

INDUSTRIAL ENGINEERING



The Department of Industrial Engineering and Management Sciences is a leader in the science of decision-making in complex environments through innovation in algorithms, computation, and mathematical modeling.

LEADING DECISION-MAKING IN THE AGE OF MACHINE LEARNING

As artificial intelligence and machine learning become more integrated into daily lives, IEMS faculty members are improving decision-making and addressing societal challenges across industries, businesses, and disciplines.

"WE'RE DEVELOPING ENABLING TECHNOLOGIES. NOT ONLY ARE OUR ALGORITHMS USED IN ALL THESE DIFFERENT INDUSTRIES, THEY ALSO MAKE IT POSSIBLE FOR SCIENTISTS AND ENGINEERS TO DO NEW RESEARCH."

ANDREAS WÄCHTER Professor of Industrial Engineering and Management Sciences

THE FAR REACH OF IEMS ALGORITHMS

Building a chemical plant. Developing an airline route. Modeling the shapes of proteins.

Each of these endeavors requires optimization algorithms: the combination of math and theory translated into code that ultimately finds the best way to design, plan, or perform an action. While engineers often develop algorithms for specific uses, two IEMS professors have earned the distinction of having developed optimization algorithms that are used broadly across industries and scientific disciplines.

L-BFGS and KNITRO, developed by Jorge Nocedal, and Ipopt, developed by Andreas Wächter, have been used in everything from designing computer chips to modeling pandemics to understanding the effects of climate change on arctic ice.

Optimization algorithms take a problem—the best airline route from Chicago to Atlanta, for example—and consider variables, like air traffic and wind, before presenting the optimal solution.

Nocedal developed L-BFGS after realizing that an existing optimization algorithm called BFGS could not be applied to problems with numerous variables. He tried to solve this throughout graduate school and succeeded only after becoming a faculty member and realizing the algorithm could not retain everything it learned, because that would exceed the capacity of every computer. Instead, it needed to retain only a limited amount of relevant information, called limited memory—the "L" in L-BFGS.

"My modification of the algorithm allowed it to solve problems with millions of variables," says Nocedal, Walter P. Murphy Professor of Industrial Engineering and Management Sciences. But this was before big data and its usefulness were widely understood. Nocedal kept refining it based on his increasingly deeper understanding of the problem. In the 1990s, the algorithm became popular with weather forecasters, and when machine-learning research took off 20 years later, the use of the algorithm accelerated.

Now, most everyone in the field of machine learning knows the term L-BFGS. Recently, the algorithm was used as part of the Google DeepMind project to help determine the 3D shapes of proteins—a breakthrough that could lead to major advances in biology and drug discovery. It was also used early in the pandemic by the federal government to model the COVID-19 pandemic's trajectory.

In the 1990s, Nocedal also began developing another nonlinear optimization algorithm called KNITRO. This algorithm took even longer to develop than L-BFGS and could solve more complicated problems with more restrictions. He and his graduate students ultimately commercialized the algorithm as software. Now, KNITRO is widely used in the energy, finance, economics, and robotics sectors.

Enabling new technologies with Ipopt

KNITRO has a companion in Ipopt, the nonlinear optimization algorithm developed by Wächter using a different algorithm than KNITRO. Wächter, professor of industrial engineering and management sciences, began developing the algorithm in the late 1990s when he was a chemical engineering graduate student. He continued working on Ipopt at IBM, where it became an open-source project.

For years, he used math, theory, and computer programming to test and refine Ipopt. When it was translated into the C++ programming language, it became known as the go-to open-source nonlinear optimization algorithm.

Wächter regularly hears about new applications of the algorithm—running trains, optimizing power grids, building chemical plants, developing airline routes, enhancing medical imaging, and even creating models of black holes.

"We're developing enabling technologies," he says. "Not only are our algorithms used in all these different industries, they also make it possible for scientists and engineers to do new research."

Both Nocedal and Wächter continue to develop new algorithms. The future, Nocedal says, lies in algorithms that can deal with uncertainty. One rich source of new problems is in machine learning where optimization must be performed in the presence of uncertainty in the data. Given the explosive growth of artificial intelligence, the demand for more capable optimization algorithms will only increase with time.

EMILY AYSHFORD

"Our work opens new pathways to the understanding and discovery of this class of materials."

JAMES RONDINELLI Morris E. Fine Professor in Materials and Manufacturing

AI-BASED TOOLS TO ACCELERATE ELECTRONIC MATERIALS DISCOVERY

One of the keys to designing new computer architectures, and to making current microelectronic devices faster and more energy efficient, has been the discovery of new materials with tunable electronic properties.

Materials that exhibit a metal-insulator transition (MIT) could pave the way for future information-processing devices, display, and energy harvesting applications. Although some materials that exhibit MITs have already been implemented in electronic devices, fewer than 70 are known, and even fewer exhibit the performance necessary for integration into new electronic devices.

An interdisciplinary team of scientists from IEMS and the Department of Materials Science and Engineering used artificial intelligence techniques to build new, free, and easy-to-use tools that allow scientists to accelerate the rate of discovery and subsequent study of materials that exhibit MIT. The team also identified new features that can describe this class of materials.

The project was led by James Rondinelli, Morris E. Fine Professor in Materials and Manufacturing, and Daniel Apley, professor of industrial engineering and management sciences.

Combining their knowledge of MIT materials with natural language processing, the researchers scoured existing literature to identify the known MIT compounds, as well as 300 materials that are similar in chemical composition but do not show an MIT. The team has provided the resulting materials—as well as features it's identified as relevant—to scientists as a freely available database for public use.

Using machine-learning tools, the scientists then identified important features to characterize these materials. They confirmed the importance of certain features, such as the distances between transition metal ions or the electrostatic repulsion between some of them, as well as the accuracy of the model.

The team used that information to develop a reliable machine-learning model for MIT materials, which has been packaged into an openly accessible format. "Our work opens new pathways to the understanding and discovery of this class of materials," Rondinelli says.

BRIAN SANDALOW

HELPING BUSINESSES CAPITALIZE ON THE INTERNET OF THINGS

The "things" that comprise the Internet of Things (IoT)—mostly physical devices embedded with sensors and software that enable them to connect over the internet with other systems to share data—are becoming ubiquitous.

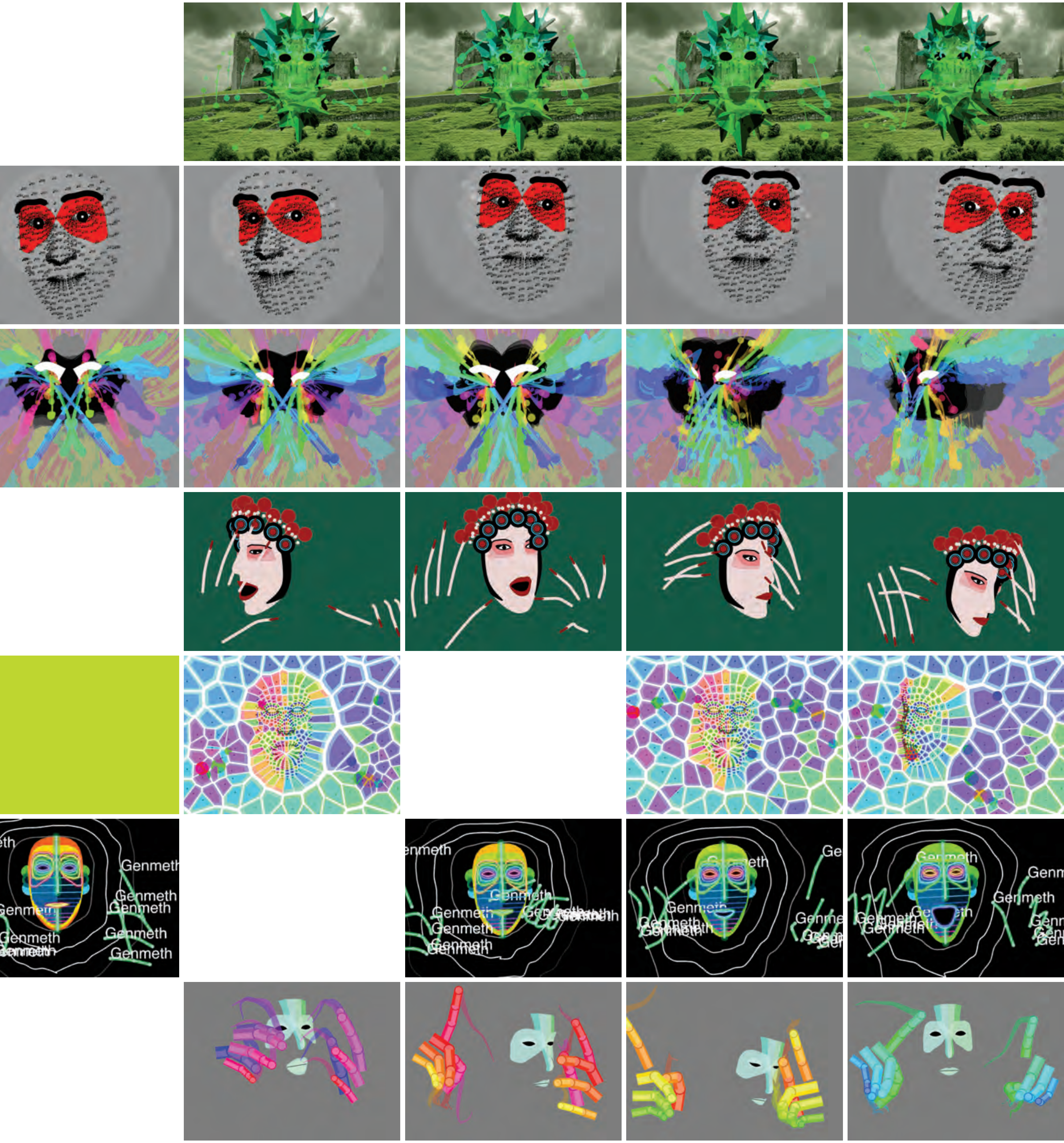
Northwestern Engineering professors have crafted a new system that allows all businesses to capitalize on this burgeoning IoT ecosystem. REFIT, developed by Northwestern's Center for Deep Learning and built by the McCormick School of Engineering's computer science and industrial engineering and management sciences departments, combines the University's machine learning and data science research with state-of-the-art artificial intelligence to produce predictive results.

REFIT ingests device and real-time business data and employs modern machine-learning approaches to infer the status of various IoT system components. The system allows users to develop, experiment, and deploy a powerful IoT framework quickly that makes work done by IoT components more efficient and with the same resources. The design allows REFIT to evolve and continuously improve its predictive abilities, while not disrupting the deployment of the current machine-learning or deep-learning approaches.

REFIT is especially useful for data scientists and engineers in companies with limited in-house resources. For example, current applications include determining real-time street traffic flows and predicting demand of Divvy bikes at stations.

"Data engineering is one of the most despised tasks," says Diego Klabjan, professor of industrial engineering and management sciences and director of the Center for Deep Learning. "Northwestern's system facilitates it by automatically generating a variety of statically based features from streaming IoT data and by using a single point of logic for features throughout the system during training or real-time scoring."

BRIAN SANDALOW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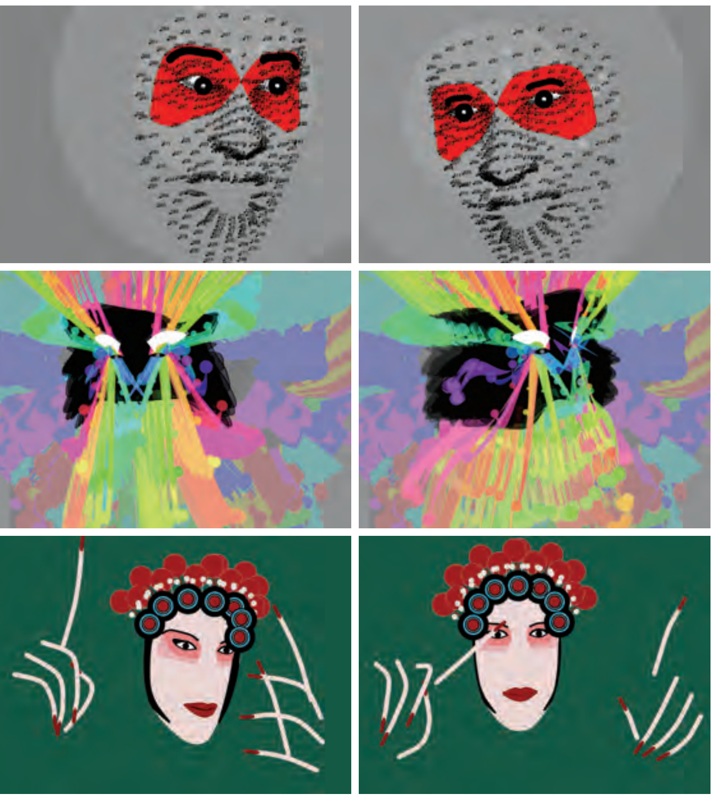


Coding Brings Costumes to Life

A new generative methods class bridges programming and theater to create virtual costumes with distinctive personalities of their own.




On the screen, an animated Chinese opera mask decorated with red pom-poms and pearls moved side to side. Its mouth opened and shut. Spindly fingers danced next to it.

But the animation was not just a simulation: it was a virtual mask, synched precisely with the face and hand movements of Northwestern student Yangdongling Liu.

Liu, a PhD candidate studying physical chemistry, coded the costume in Generative Methods, a computer science class that explores the intersection of programming and art. In the class, taught by Kate Compton, students from other academic programs collaborated with theater design students in the School of Communication to learn how theater designers think about costuming and to find parallels in their respective disciplines.

Applying the artistic lessons they'd learned, students created virtual costumes that overlaid graphic masks and animated hands on video while tracking their body and face movements.

Blending computer science and art comes naturally to Compton, a generative artist and assistant professor of instruction in computer science at Northwestern Engineering. Last fall, Compton met with Ana Kuzmanic, associate professor of costume design, to discuss a possible collaboration. "The collaboration was a way for Ana and me to communicate through our students and start to develop a common language that we both could understand," Compton says.

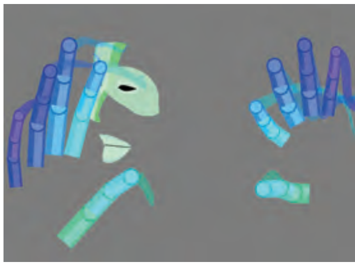
PROGRAMMING TO REFLECT EMOTIONS

During a class demonstration on Zoom, student Rohith Jayaraman pulled up a fiery mask, and spiky red flames radiated from his face. The virtual mask was inspired by a scene in J.K. Rowling's *Harry Potter and the Goblet of Fire* when Sirius Black's face appears to Harry Potter in a fireplace.

The code, he explained, reflects the emotions of the character. As he spoke, he controlled how quickly his mask's flames flickered—fast when angry and slow when happy. He learned the artistic process from theater design students, including undergraduate Hayley Wallenfeldt, designer and animator, and master of fine arts candidate Benjamin Kress, an experienced costume designer, who fashioned elaborate visual presentations to illustrate core principles of theater design.

"Art doesn't come to me," says Jayaraman, a master of science in computer science student. "I've done a lot of programming, but I've never been able to bring something cool up on screen like this. There's something different about creating a program versus creating something fun people can play with."








"THE REAL FUN OF THESE MASKS IS THAT THEY ARE INTERACTABLE LIVE."

KATE COMPTON
Assistant Professor of Instruction in Computer Science

A FOUNDATION FOR MEANINGFUL COLLABORATION

With code, costumes can even take on their own, asynchronous personalities. In some ways, virtual costumes become characters themselves.

"Imagine if your costume is moving, and then it winks at you," Compton says. "There's a character in your costume that's very alive and sharing your face with you. It tears apart the connections we've assumed about the body."

The possibility of virtual mask technology becoming more involved in theater productions is exciting, Compton says. "It'd be really amazing for a 'Jekyll and Hyde' production to include a virtual mask projected onto an actor, and then someone offstage with a joystick taking control of the actor's face.

"I think the real fun of these masks is that they are interactable live," Compton adds. "There are plenty of prerecorded videos used on stage, but this would let live actors and mask 'puppeteers' improvise playfully, like the Muppets do."

This type of interdisciplinary collaboration is a hallmark of Northwestern's mission. To Kuzmanic, much can be learned from the ways people from different fields think creatively and approach problem-solving.

"On the surface, our fields might be perceived as opposites," Kuzmanic says. "Fundamentally, while we speak different languages in terms of our respective disciplines, there are great similarities in our individual ways of generating and delivering information, and those similarities provide the foundation for meaningful collaboration."

ERICA MASINI





CLASS NOTES

VISUALIZING A CRYPTOCURRENCY FUTURE

SCOTT KNUDSEN APPLIES HIS DISRUPTIVE MINDSET AND PROBLEM-SOLVING SKILLS HONED AT NORTHWESTERN ENGINEERING TO SEIZE A NEW OPPORTUNITY.

"THE'RE LOOKING FOR HELP AND ADVICE ON HOW TO GROW. I JUST HAVE SO MUCH PRIDE AND LOVE FOR NORTHWESTERN, SO WHY NOT DO IT?"

An engineering mindset is valuable in almost any field. Using strong analytical skills, engineers solve problems and optimize processes. At the same time, they must be creative enough to visualize solutions that might not be obvious.

Scott Knudsen ('03) not only exemplifies those qualities, he has also built businesses on them.

"People in any industry like to hire engineers because they have an ability to solve problems," Knudsen says. "They have skills and an approach that can be adapted to any challenge put in front of them."

Knudsen, an electrical engineering graduate, spent 14 years at IMC Trading, rising to partner and head of the US business. While he was there, IMC Trading hired employees with a computer science background to build the company's own hardware and network components, allowing the firm to control its equipment and process financial data more efficiently.

In 2017, Knudsen visualized another opportunity in an area ripe for innovation: cryptocurrency.

With a disruptive mindset and plenty of contacts, Knudsen co-founded Cove Markets. Cove develops trading software that connects multiple crypto exchange accounts and provides tools and algorithms for the active traders.

"Any time you start a new business, you know what the risk of failure is, but I felt like this could be my chance to build a company from scratch," Knudsen says. "This could be my own vision, and I can actually own this and be in control of it, which was a really empowering idea.

"This new business was the first time in 15 years that I felt like a fresh graduate again because you're learning so many things from so many successful people in the space," Knudsen adds. "It felt like I was 24 years old and back in the mix trying to prove myself again."

Knudsen is also giving back to the Northwestern Engineering community. In 2017, he joined the Electrical and Computer Engineering Advisory Board to network with faculty, alumni, and students. He hopes to play a role in the McCormick School of Engineering's future, since it influenced his life and career so much.

"The're looking for help and advice on how to grow," Knudsen says. "I just have so much pride and love for Northwestern, so why not do it?"

That attitude has served Knudsen well.

BRIAN SANDALOW

Technical Translator

WHETHER MAKING AIR TRAVELERS COMFORTABLE OR CONVEYING COMPLEX SCIENTIFIC FINDINGS, **KATERI GARCIA** STILL RELIES ON THE SKILLS SHE LEARNED AT NORTHWESTERN.

As an undergraduate in industrial engineering and management sciences, Kateri Garcia ('00) learned about efficiency, analysis, and best business practices.

She also studied Spanish, and in those courses, she was exposed to students who saw things from a different perspective. Both tracks helped launch her academic and professional careers.

"Those experiences helped me communicate scientific information and convey value to any audience," Garcia says.

Garcia's first job after Northwestern Engineering was as a corporate planning analyst at JetBlue Airways, then a startup airline. Garcia was responsible for designing and managing data collection projects and presenting results of data analysis to company executives. There, she also pursued her dream of working as an inflight crewmember, which helped her develop strong customer service skills.

"It was an invaluable experience that put me in a lot of challenging situations," she says. "When you're in the air there are not a lot of options to make people comfortable and happy. Instead, you have to find unique solutions with the space and tools at hand."

Following JetBlue, Garcia received a Boren Fellowship to study in Uruguay and earned her master's degree at the University of New Mexico in Latin American studies. She then landed at the National Geospatial-Intelligence Agency, which operates under the US Department of Defense to deliver geospatial intelligence to policy makers, intelligence professionals, and first responders.

Garcia leads a team of image scientists who support the advancement of three-dimensional remote sensing capabilities like Lidar—Light Detection and Ranging—in order to describe, assess, and visually depict physical features and human activity on Earth. Making new technology accessible is complicated. It must be done through constant collaboration and communication, and with a deep understanding of organizational dynamics and their effect on decision-making.

To do so, she uses skills she picked up at Northwestern and honed during her career. "It's been critical in my career to take highly technical and scientific developments and translate that into language people understand so they can make well-informed decisions," she says.

BRIAN SANDALOW

"It's been critical in my career to take highly technical and scientific developments and translate that into language people understand so they can make well-informed decisions."

Creating Immediate Impact

McKinsey's **Megan Greenfield** solves complex problems to drive positive change

As a partner at global consulting firm McKinsey & Company, Megan Greenfield (PhD '09) searches for solutions to some of the world's most challenging business and social problems, from improving healthcare to advancing equity in the workplace.

"What I love about being able to work on the hardest problems is that you really feel like you can make a big difference," she says, "and you can make it fast."

That's what drew Greenfield out of the Northwestern lab, where as a chemical and biological engineering graduate student she conducted research in biomaterials and tissue engineering. Although she appreciated the University's collaborative, interdisciplinary approach, she found the prospect of helping people in real time more appealing than the slower process of academic research.

"I love research, but it takes forever to have an impact," she says. "As a consultant, I can do things that impact people immediately."

Since joining McKinsey in 2010, Greenfield has used her biotech expertise to help healthcare clients, including large health systems and life sciences companies, create strategies, tools, and organizational structures to drive growth and efficiency. Most recently, she has expanded beyond healthcare to address the economic effects of COVID-19.

CREATING A NEW MODEL

Greenfield helped design one of the first state-level COVID-19 economic recovery plans in the United States. It's a framework that has been adopted by many states, cities, and organizations nationwide.

As businesses began to close in March 2020, Greenfield's team considered ways to reopen the economy well before the full extent of the pandemic was even known. With no existing model to study, the team had to create one.

"Our objective was to figure out how to reopen as quickly and safely as possible so that we didn't crush the economy," she says. "We assessed each industry, looking at its economic importance, ability to shift activities to remote settings, and specific health risks in order to think through the right sequence for how to reopen and what protections should be put in place to keep employees and customers safe."

Her team identified a range of safety precautions to help leaders think through the options on what protections to put in place, pulling ideas from previous pandemics as well as the emerging experience in China and Italy, which were a few months ahead of the United States in facing COVID-19. "We didn't come up with policy—we never do," she explains. "We helped structure how to think about the different dimensions of the situation, so that government and community leaders could decide what to do. It was a fascinating, very interdisciplinary project."

“ENGINEERING IN PARTICULAR IS ABOUT FIRST FIGURING OUT WHAT THE PROBLEM IS, THEN HOW TO SOLVE IT, AND FINALLY HOW TO GET PEOPLE ON BOARD TO DRIVE CHANGE. THAT’S BASICALLY WHAT I DO EVERY DAY.”

DRIVING ENDURING CHANGE

The variety of projects and the constant learning are what Greenfield enjoys most about her role at McKinsey. “I work with a wide range of companies on a wide range of problems with a wide range of different people, so it’s always something new,” she says.

Inspired by her employer’s purpose to create positive, enduring change in the world, Greenfield advances the company’s diversity, equity, and inclusion initiatives. She is involved with Women in the Workplace, an annual research study by LeanIn.Org and McKinsey, and helps institutions develop strategies to improve recruiting, promotion, and retention of diverse talent. She leads the Massachusetts High Technology Council’s Women in Leadership Initiative, which involved hosting numerous executive roundtables and writing several white papers. This year, she is conducting research into how employers can address health inequities among their employees and is designing a global program to help multinational companies address gender inequality.

She is also a visible leader within McKinsey, co-leading the firm’s Greater Boston Inclusion, Diversity, and Equity team and Women’s initiative. Last year, she helped launch McKinsey’s Greater Boston Allyship Network, which piloted the firm’s first anti-racism training.

Greenfield has been driving change since her time at Northwestern Engineering, where she co-founded the McCormick Graduate Leadership Council in 2006 with Binoy Shah (PhD ’09) to promote a sense of community among McCormick graduate students. Greenfield also served as president of Northwestern’s Graduate Student Association, where she helped improve students’ health insurance benefits.

SOLVING PROBLEMS AND GETTING STAKEHOLDERS ON BOARD

Taking on a complex issue like health insurance as a student isn’t that far from the work she does today, Greenfield says. She applies the same problem-solving skills she learned at Northwestern to all her projects.

“Engineering in particular is about first figuring out what the problem is, then how to solve it, and finally how to get people on board to drive change,” she says. “That’s basically what I do every day.”

Her efforts earned her an appointment to the World Economic Forum’s Forum of Young Global Leaders in 2021, a recognition bestowed on around 100 promising artists, business leaders, public servants, technologists, and social entrepreneurs each year. She joins a five-year program that will challenge her to shape a more inclusive and sustainable future.

“It’s a very special group of people with fascinating backgrounds and experience,” she says. “It’s an honor that I get to be part of it.”

SARA LANGEN

RISE AND SHINE

SCIENCE-BACKED RISE APP AIMS TO HELP PEOPLE BECOME HEALTHIER, HAPPIER, AND WELL RESTED BY GAINING CONTROL OF THEIR ENERGY LEVELS.

Jeff Kahn

Leon Sasson

As an engineering student with a heavy workload and crammed schedule, Jeff Kahn ('13, MS-EDI '15) woke up exhausted most days. His mood and productivity levels were low, and he started to wonder whether his sleep had something to do with it.

He was right. Sleep deprivation can wreak havoc on mental and physical health, and almost half of all Americans say they feel sleepy at least three days a week, according to a 2020 National Sleep Foundation poll.

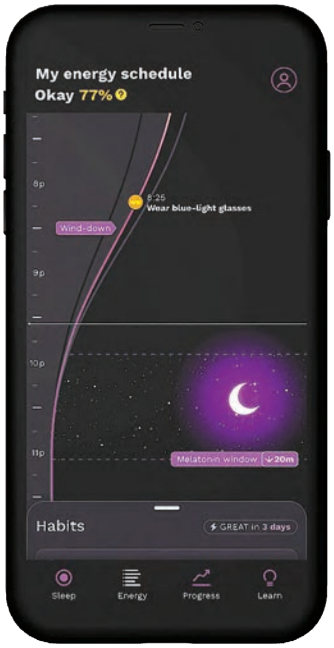
Enter Rise Science, an energy optimization company cofounded in 2015 by Kahn and Leon Sasson ('15). The company's RISE app, launched over this past summer, helps users improve their sleep and harness their daily energy levels.

Instead of just tracking sleep data, as other sleep apps in the market do, RISE goes a step further. Based on the two-process model of sleep regulation—which takes into account both circadian rhythms and sleep debt—the app shows users at what times their energy levels will be high and low throughout the day. It also suggests how to change daily behaviors to optimize energy levels and get the amount of sleep they need.

FOCUSING ON SOLVING THE RIGHT PROBLEM

RISE is grounded in sleep science, an area of study Kahn dove into during his sophomore year. Though he was an engineering student, Kahn discovered he could customize his curriculum by pursuing combined studies in health systems engineering. Driven to learn as much as possible about sleep, Kahn set up independent studies with sleep scientists at the Feinberg School of Medicine, while poring over sleep studies and enrolling in sleep seminars.

> **"So much of what we do as a company today is applied research. Complex systems, statistics, and probability are fundamental to running the company, and I didn't understand how that worked before McCormick. I gained a lot of confidence as a builder."**
>
> **JEFF KAHN**



"It was freeing to be able to take classes that really mattered to me and that applied directly to my work," Kahn says. "Once I focused on a problem I really wanted to solve, that was a huge turning point."

Around that time, he met Sasson, a computer science and industrial engineering student, and the two started talking about the importance of sleep. Sasson says, "Jeff convinced me that sleep is so important. As engineering students, we had very late nights in the computer lab and then 8 a.m. classes. I realized I was basically operating as if I were drunk all the time from a cognitive perspective."

After learning the sleep science behind why they felt tired, Kahn and Sasson set up an independent study with Dan Brown, clinical professor at the Segal Design Institute. Brown, who teaches human-centered design, helped Kahn and Sasson apply the scientific sleep principles they learned into designing a product for people.

During spring finals week of their sophomore year, Kahn and Sasson met with the Northwestern football team. Tory Lindley, former senior associate director of athletics, asked them to roll out a solution to help all the team's players improve their performance on the field by improving their sleep—and do it in time for training camp in August.

Starting that summer, Kahn and Sasson dove headfirst into building technology, conducting research, publishing papers, and delivering a product. After that, they got contracts with major college and professional sports teams and began to consider whether there was a space in the market for non-athletic applications.

Turns out there was. The beta version of the RISE app, launched in 2020, has been downloaded by more than 1 million users around the world. Now, Rise Science is celebrating its latest milestone: a $15.5 million funding round that includes $10 million in new Series A funding and a previous $5.5 million in seed round participation.

LEANING ON A NORTHWESTERN NETWORK

Kahn plans to use the funding to continue improving the technology. "So much of what we do as a company today is applied research," Kahn says. "Complex systems, statistics, and probability are fundamental to running the company, and I didn't understand how that worked before McCormick. I gained a lot of confidence as a builder."

Growing their network was also a key factor in the duo's success. Sasson and Kahn met Northwestern alumnus Mert Iseri ('11), cofounder of healthcare startup SwipeSense, who mentored the pair, and they still have a small network of other Northwestern founders they call on for advice and connections. "Graduating from school, you have no connections, so this network was a great bridge to the tech industry at large in Chicago," Sasson says.

"We wouldn't be here without McCormick being open to our doing all of these things," Kahn says. "From conducting combined studies to getting research funding to co-opting our project to having access to all these close connections with people who supported us and believed in us, we've been so incredibly lucky."

ERICA MASINI

IN MEMORIAM

Professor Allen Taflove

Pioneer, innovator, and thought leader, Taflove made worldwide impact with his work on the finite-difference time-domain method

Allen Taflove, professor of electrical and computer engineering at Northwestern Engineering who conducted pioneering work in the finite-difference time-domain (FDTD) method, passed away at age 71 on April 25, 2021. He will be remembered for his groundbreaking research and dedication to education and advising.

Taflove's roots at the McCormick School of Engineering ran deep: he received his bachelor's, master's, and PhD degrees here. After serving as a researcher at IIT Research Institute, Taflove returned to Northwestern in 1984 and became a full professor in 1988.

In research, Taflove developed fundamental theoretical approaches, algorithms, and scientific and engineering applications of FDTD computational solutions of the fundamental Maxwell's equations of classical electrodynamics. He was celebrated by the IEEE, becoming the first fellow for FDTD technique work as well as receiving the group's Electromagnetics Award. His groundbreaking research has been applied to a vast array of research areas from interactions of electromagnetic waves with tissues, to low-observable (stealth) aircraft, to fundamental physics.

Along with serving as author or co-author of 27 articles or chapters in books and magazines, 152 refereed journal papers, and 14 US patents, his book, *Computational Electrodynamics: The Finite-Difference Time-Domain Method*, ranked as the seventh most-cited book in physics with close to 21,000 citations.

"While many of us hope that our papers may be remembered once we are gone, Allen was able to see the tremendous impact of his landmark book," says Julio M. Ottino, dean of Northwestern Engineering. "This book, one of the most cited books in physics, will survive him. We should all hope our research has such a deep and wide scope of influence."

In recent years, Taflove collaborated with Vadim Backman, Sachs Family Professor of Biomedical Engineering and Medicine, to develop a minimally invasive spectroscopic microscopy technique for detecting early-stage cancers.

"One of the reasons why I wanted to become a faculty member at Northwestern back in 2001 was because of Allen. I had been admiring his work," Backman says. "Allen's work, friendship, and mentorship have touched so many lives. He is an example of what a beautiful life must be like."

"Allen was an incredible asset to Northwestern Engineering," says Randall Berry, chair and John A. Dever Professor of Electrical and Computer Engineering. "He was a great colleague who clearly loved his work and cared deeply about our students."

Taflove is one of the only faculty members to win Northwestern Engineering's advising award twice, and in 2006, he won both the teaching and advising awards. He served as adviser or co-adviser of 24 PhD recipients and five postdoctoral fellows along with a host of undergraduate students.

"Allen's pioneering contributions to time-domain computational electromagnetics were revolutionary. He was a true giant in the field," says Susan Hagness, Philip Dunham Reed Professor and chair of the electrical and computer engineering department at the University of Wisconsin-Madison. Taflove was her undergraduate research adviser and PhD adviser. "But even more profound is the educational impact he had on countless students over his 37-year career as a professor. He was always there for his students, exuding boundless enthusiasm and support of their learning."

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BIG IDEA

The case of the aquarium's disappearing medicine

For months, veterinarians put medicine into the animals' quarantine habitats at Chicago's Shedd Aquarium, ensuring that animals entering the building did not bring dangerous pests or pathogens with them. And for months, the medicine consistently kept disappearing.

To help solve this mystery, researchers at Shedd Aquarium partnered with Northwestern University microbiologists to collect clues, follow leads, and ultimately track down the culprit.

After conducting microbial and chemical analyses on samples from the saltwater aquarium systems, the team found it was not just one culprit but many: a family of microbes, hungry for nitrogen.

"Carbon, nitrogen, oxygen, and phosphorous are basic necessities that everything needs in order to live," says Northwestern Engineering's Erica M. Hartmann, assistant professor of civil and environmental engineering, who led the study. "In this case, it looks like the microbes were using the medicine as a source of nitrogen. When we examined how the medicine was degraded, we found that the piece of the molecule containing the nitrogen was gone. It would be the equivalent to eating only the pickles out of a cheeseburger and leaving the rest behind."

Photography by Jason Brown

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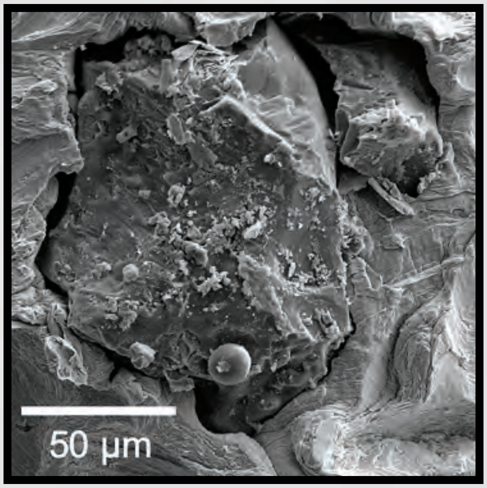

BIG INSIGHTS FROM A SMALL SAMPLE

Northwestern engineers and researchers from the Field Museum in Chicago joined forces to study the atomic structure and chemical makeup of lunar soil. Using an atom probe tomograph housed in the Northwestern University Center for Atom-Probe Tomography, the team analyzed a single grain of soil—about the width of a strand of human hair—that was part of a sample collected during the Apollo 17 Moon landing. They found evidence of exposure to solar and cosmic radiation, which could help scientists better understand the composition of other materials in our galaxy. Read more about the collaboration on page 14.

Photography by Jennika Greer, Field Museum