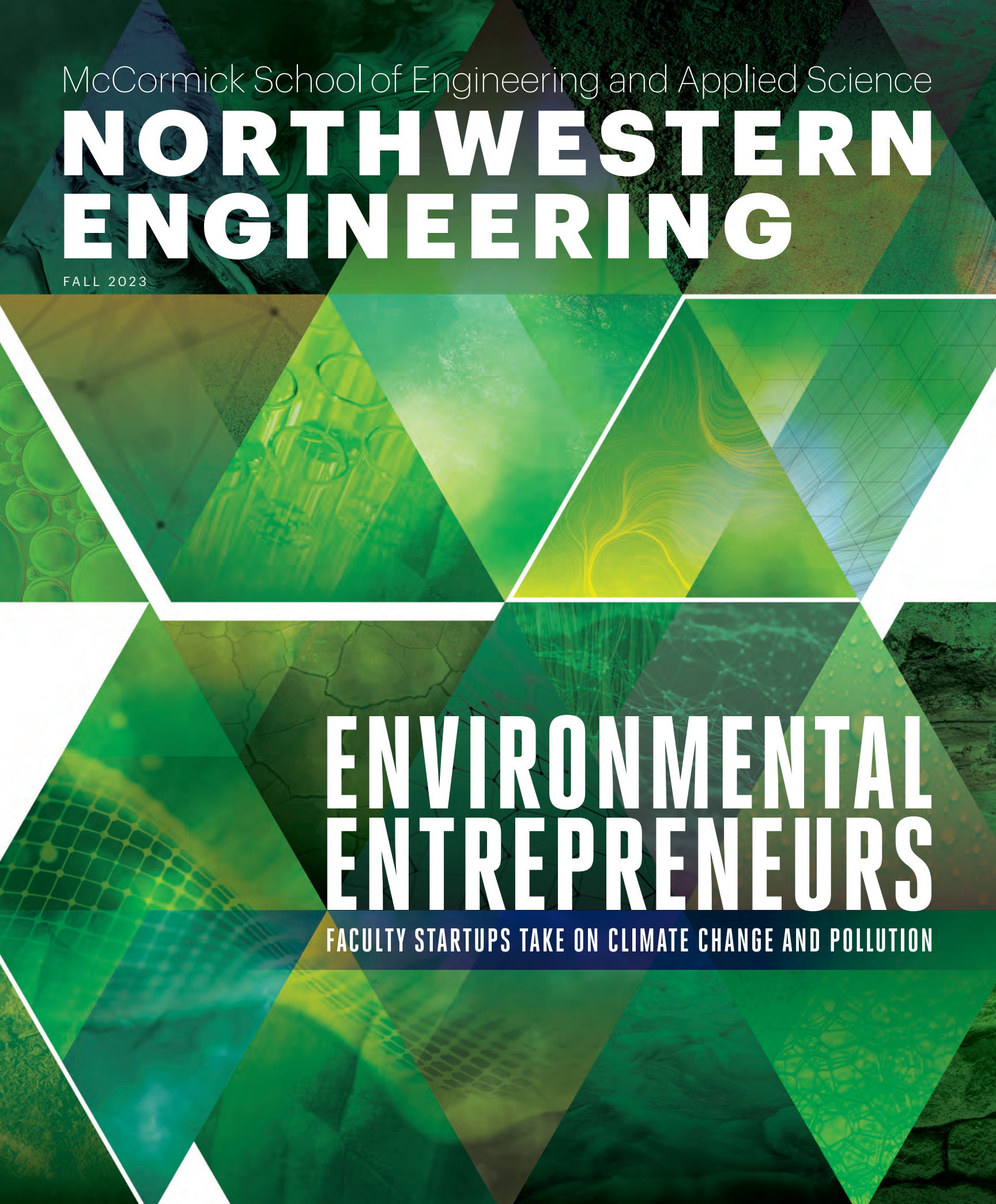
McCormick School of Engineering and Applied Science

NORTHWESTERN ENGINEERING

FALL 2023



ENVIRONMENTAL ENTREPRENEURS

FACULTY STARTUPS TAKE ON CLIMATE CHANGE AND POLLUTION


Northwestern
University

A Dean's Welcome for McCormick's Largest Class

Northwestern Engineering's class of 2027—the school's largest ever—packed into the Technological Institute's Ryan Family Auditorium on September 13 to hear from Dean Christopher Schuh. During his interactive talk, Schuh asked students to point in the direction that represented their dominant way of thinking—left, representing left-brain logic and analysis; or right, representing right-brain creativity and subjectivity. Schuh explained that it is the school's mission to help students learn to combine both ways of thinking to maximize their impact on the world.

The event, part of the University's Wildcat Welcome orientation, marked Schuh's first in-person address to engineering students as dean. Learn more about Schuh on page 22.

Photography by Matthew Allen

"It is essential to support those you serve by giving them freedom to focus on their passions and take risks. Only then can they unleash their talents in the most innovative ways, ultimately redefining the directions of their fields."

TWENTY-FIVE YEARS AGO, when I arrived at the McCormick School of Engineering as a graduate student in materials science, I knew I had found the right place. The school's unique culture and systems gave me the flexibility to explore and room to grow.

That not only facilitated my educational and research journey, but it taught me a valuable lesson for the leadership roles I've held in my career: It is essential to support those you serve by giving them freedom to focus on their passions and take risks. Only then can they unleash their talents in the most innovative ways, ultimately redefining the directions of their fields.

As I returned to Northwestern Engineering as dean this fall, I found an even stronger school that had been nurtured by Dean Julio M. Ottino's enduring whole-brain engineering vision. Faculty, students, and alumni are all striving to use their unique skill sets to collaborate and tackle the complex challenges of our time.

In this issue, you'll find many examples of that. Our computer science faculty are teaming up with the Pritzker School of Law to understand the possibilities and limits of generative AI programs like ChatGPT. Professor Q. Jane Wang, who was recently elected to the National Academy of Engineering, is using her deep expertise in the study of friction to help design better electric vehicles. And several of our faculty have not only created solutions for a more environmentally sustainable future—they've launched startups to commercialize their ideas and move them out into the world. This sort of vertical integration is essential to ensure the technologies we develop are adopted by society to make real impact.

Maintaining that tenet of leadership I learned so many years ago—help when needed, otherwise get out of the way—I have begun meeting with departments, offices, and groups across the school to identify how we can further refine and grow Northwestern Engineering. It has been exciting, to say the least. Soon, I look forward to also connecting with alumni as we look to leverage all of our strengths and have the broadest possible impact.

This is going to be fun.

CHRISTOPHER A. SCHUH
Dean, McCormick School of Engineering and Applied Science

On the Cover
Northwestern Engineering faculty members are taking their sustainable innovations out of the lab and into industry to help mitigate the effects of climate change and pollution. See story on page 12.

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

Northwestern | McCORMICK SCHOOL OF ENGINEERING

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Produced by The Grillo Group, Inc.


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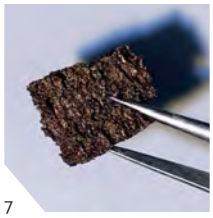
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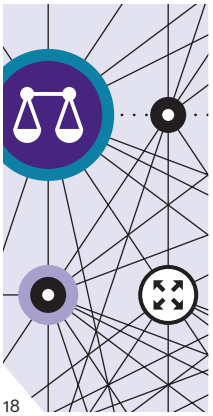
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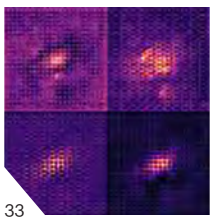
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NORTHWESTERN ENGINEERING
FALL 2023

NEWS

MATERIALS RESEARCH SCIENCE AND ENGINEERING CENTER RECEIVES $18 MILLION NSF GRANT

Northwestern's Materials Research Science and Engineering Center, among the longest continually funded materials research centers in the country, has received a six-year, $18 million grant from the National Science Foundation.

The grant will support two projects. One will develop soft composite materials that incorporate biological machinery in a cell-free platform, removing the nourishment and care demands of living tissue. Achieving functionality of living biological systems in autonomous materials has direct implications for sustainable agriculture, water treatment, smart clothing, and wound healing.

Another project will design materials that concurrently conduct ions and electrons, behaving in a manner that mimics biological neurons. These hybrid ionic/electronic conductors allow brain-inspired computation that will accelerate advances in artificial intelligence, robotics, and bioelectronics.

"PRESENTING SCIENCE AND TECHNOLOGY THROUGH ARTS AND PERFORMANCE HAS PROVEN TO HAVE A PROFOUND OUTREACH EFFECT, CAPTURING THE IMAGINATION OF DIVERSE AUDIENCES AND INSPIRING THE NEXT GENERATION OF SCIENTISTS AND ENGINEERS."

ERMIN WEI Associate Professor of Electrical and Computer Engineering and Industrial Engineering and Management Sciences

Exploring Alan Turing's Life

Through the generous support of several sponsors, a group of 124 Northwestern Engineering students and 11 faculty and staff members attended Chicago Opera Theater's performance of *The Life and Death*(s) *of Alan Turing*.

The outing was organized by Northwestern Engineering's ETOPiA. The Engineering Transdisciplinary Outreach Project in the Arts uses performance arts to inspire a cross-disciplinary dialogue about the role of science and technology in society.

Considered the father of computer science, Turing was instrumental in breaking naval ciphers coded by Germany's Enigma machine, enabling critical victories during World War II. After the war, Turing was charged with gross indecency for acknowledging a homosexual relationship and was subjected to chemical castration.

ETOPiA events often highlight the pursuit and application of knowledge by individuals, like Turing, whose historical and personal circumstances range from tragic to epic.

5

Engineering faculty and graduate students who traveled to Nairobi for the latest Joint Undertaking for an African Materials Institute program, which connects researchers from the US and Africa

100 MICRONS

Thickness of a new graphene cardiac implant developed by Igor Efimov

Northwestern Establishes Julio M. Ottino Professorship

In recognition of former dean Julio M. Ottino's leadership and long-term commitment to the University and the McCormick School of Engineering, Northwestern has created the Julio M. Ottino Professorship.

Members of the McCormick Advisory Council, alumni, and other supporters made gifts to Northwestern to create the professorship in Ottino's honor.

"I am incredibly grateful to the Northwestern community for this wonderful honor," Ottino says. "This professorship is a testament to all of the successes we achieved together as a school during my tenure as dean."

Engineering Student Startup Wins VentureCat Grand Prize

Cue the Curves, a plus-size shopping app startup founded by Northwestern Engineering student Charlotte Oxnam, won the $150,000 VentureCat grand prize.

Held May 31, VentureCat is an annual University-wide pitch competition and collaborative program. Oxnam, CEO of Cue the Curves, graduated in June with a degree in industrial engineering. She participated in The Garage's Residency and Propel programs.

$6.25 MILLION

Department of Defense grant given to a team that includes Jonathan Rivnay to improve biohybrid actuators

$45 MILLION

Funding from the Advanced Research Projects Agency for Health given to a multi-institutional team that includes Northwestern to develop an implant that can sense and treat cancer

RODNEY D. PRIESTLEY CHALLENGES GRADUATES TO USE EDUCATION FOR GOOD

Rodney D. Priestley (PhD '08), speaking at Northwestern Engineering's 2023 PhD Hooding and Master's Recognition Ceremony on June 11, encouraged graduates to make impressions count, generate new ideas, and strive to be innovators.

Now a professor at Princeton University and dean of its Graduate School, he recounted how as a graduate student he was so excited about his experiments that he got to his lab around 5 a.m. only to find his professor was already there.

"Your actions—whether arriving early to the lab (as I did most days, but certainly not at 5 a.m.) or ensuring that you treat everyone with dignity and respect, or insist on creating opportunities for others—tell those around you about your character without saying a word," he said.

NORTHWESTERN, IIT BOMBAY PLEDGE COLLABORATION TO ADVANCE EDUCATION, RESEARCH

Underscoring the value of interdisciplinary scientific research and promoting enhanced collaboration between higher education in the United States and India, officials from Northwestern and the Indian Institute of Technology (IIT) Bombay signed a memorandum of understanding (MOU) pledging an earnest commitment to work together to foster new opportunities for students, researchers, and scholars alike.

Northwestern University Provost Kathleen Hagerty and Subhasis Chaudhuri, director of IIT Bombay, endorsed the MOU at IIT Bombay's Faculty Alumni Network and Distinguished Alumni Meeting hosted at Northwestern's Norris University Center on July 8.

The meeting was organized by Professor Neelesh Patankar, a 1993 IIT Bombay alumnus, with support from the Chicago chapter of IIT Bombay alumni and the office of Ravi Gudi, dean of alumni and corporate relations at IIT Bombay.

With a commitment to sharing expertise and resources, the Northwestern-IIT Bombay MOU aims to uplift the experience and results at both institutions through efforts such as research, training, and symposia. The agreement between two of the world's premier engineering and technology universities and research institutions capitalizes on the strengths of both in ever-evolving fields such as electrical engineering, computer science, and chemical engineering.

Chaudhuri pronounced the MOU a marriage of "two beautiful minds" while Hagerty said the agreement promises to strengthen the intellectual eminence of both institutions and propel invigorating discovery.

"We at Northwestern are confident our continued collaboration with IIT Bombay ... will contribute to new and vital research," Hagerty said.

Student Team Wins Third-Place Honors at DOE Solar Decathlon

The interdisciplinary Northwestern Engineering student team engiNUity was named a 2023 Design Challenge winner in the US Department of Energy Solar Decathlon, earning third-place honors in the competition's Education Building Division.

The Solar Decathlon—which challenges students to design and construct high-performance, low-carbon buildings powered by renewable energy—promotes innovation, STEM education, and workforce development opportunities in the buildings industry. The engiNUity team was one of 55 finalists from 43 collegiate institutions that competed at the Solar Decathlon Competition Event April 20–23 in Golden, Colorado.

The team's winning design was for a renovation of Lisle Junior High School, a public middle school located about 25 miles west of Chicago. The team of 16 students—15 from the McCormick School of Engineering—aimed to modernize the facility with innovations in the floor plan, HVAC system, and water management and the incorporation of renewable systems, making the campus a sustainable, feasible prototype for other schools in the United States.

MaDE STUDENT ABDALLA BADRI NAMED CO-OP STUDENT OF THE YEAR

Abdalla Badri ('23), a manufacturing and design engineering major, completed a nine-month co-op with Apple. He contributed to six projects, where he was responsible for designing and executing user studies and for creating novel test devices.

For these achievements, Badri was named Northwestern Engineering's 2023 Walter P. Murphy Cooperative Engineering Education Student of the Year. "It was a really good experience to be in the field and see how my education prepared me for the workplace," Badri says.

"SOLAR DECATHLON HAS TAUGHT ME A LOT ABOUT APPLYING THE KNOWLEDGE WE'VE LEARNED IN CLASSES. IT'S MADE ME FEEL MORE CONNECTED TO WHAT'S GOING ON AROUND ME. WITH SOLAR DECATHLON, I WAS ABLE TO FOCUS ON SUSTAINABILITY." **POLEN TON** Civil Engineering

CHRISTINA KOSMOWSKI ENCOURAGES GRADUATING SENIORS TO SAY YES

Saying "yes" has led to so much for Christina Kosmowski ('98). It allowed her to play on Northwestern's first women's soccer team, forge personal connections, and take professional chances.

Speaking at Northwestern Engineering's 2023 Undergraduate Convocation on June 11, Kosmowski, CEO of LogicMonitor, stressed the importance of responding in the affirmative.

"Embrace the power of collaboration, nurture lifelong connections, especially the ones you made at Northwestern, and never shy away from taking risks, even if they may seem questionable at the time," she said.

"As you embark on your own paths, remember that while the world may evolve, certain foundations endure. Say 'yes' to opportunities that align with your values, ignite your passion, and test your perseverance."

CHRISTINA KOSMOWSKI
CEO, LogicMonitor

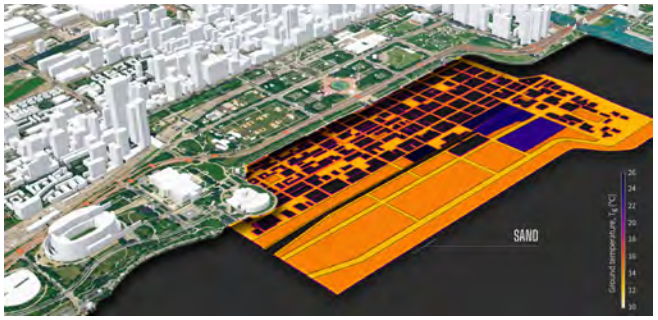
16 WEEKS

Length of the virtual coding class offered by YW Tech Lab, a partnership between YWCA Evanston/North Shore and Northwestern Engineering that aims to remove racial barriers to equitable representation of women of color in tech

HELEN OLOROSO STEPS DOWN

After more than 20 years of service, Helen Oloroso has stepped down as assistant dean and director of the McCormick Office of Career Development. She joined Northwestern Engineering in 2001 to lead the Walter P. Murphy Co-op Program. Since, she has broadened the scope of the office to support internships, research experiences, and service learning and has dramatically expanded support for graduate students. "She leaves very big shoes to fill," says Julio M. Ottino, former dean of the McCormick School Engineering.

LAB NOTES



The Ground Is Deforming, and Buildings Aren't Ready

A Northwestern study has, for the first time, linked underground climate change to the shifting ground beneath urban areas. As the ground heats up, it also expands and contracts, causing building foundations and the surrounding ground to move excessively and even crack. Ultimately, this affects structures' long-term operational performance and durability.

Although rising temperatures pose a threat to infrastructure, the researchers, led by Professor Alessandro Rotta Loria, also view it as an opportunity. By capturing the waste heat emitted underground from subterranean transportation systems, parking garages, and basement facilities, urban planners could mitigate the effects of underground climate change and transform the previously untapped resource into thermal energy. Learn more on page 17.

"Underground climate change is a silent hazard. The ground is deforming as a result of temperature variations, and no existing civil structure or infrastructure is designed to withstand these variations. Although this phenomenon is not dangerous for people's safety necessarily, it will affect the normal day-to-day operations of foundation systems and civil infrastructure at large."

ALESSANDRO ROTTA LORIA
Louis Berger Assistant Professor of Civil and Environmental Engineering

METAL-FILTERING SPONGE REMOVES LEAD FROM WATER

Researchers led by Professor Vinayak Dravid have developed a new sponge that can remove metals—including toxic heavy metals such as lead and critical metals like cobalt—from contaminated water, leaving safe, drinkable water behind. The researchers tested the new sponge on a highly contaminated sample of tap water that contained more than one part per million of lead. With one use, the sponge filtered lead to below detectable levels.

The researchers also successfully reused the sponge for multiple cycles after recovering the metals from it. The new sponge shows promise for future use as an inexpensive, easy-to-use tool in home water filters or environmental remediation efforts. The research team also set design rules for optimizing similar platforms for removing and recovering other heavy-metal toxins, including cadmium, arsenic, cobalt, and chromium.

"We could potentially design implant surfaces that would promote significantly better integration with surrounding bone, for example tissue fixation devices and hip or knee implants."

GUILLERMO AMEER
Daniel Hale Williams Professor of Biomedical Engineering

Designing Surfaces to Improve Bone Grafts

Bone implants can repair and rebuild existing bones. They can also sometimes loosen following a procedure, which can necessitate surgical revisions that lengthen recovery time.

Research by an interdisciplinary team from Northwestern Engineering's Center for Advanced Regenerative Engineering and Center for Physical Genomics and Engineering has introduced a concept—surface topography-induced chromatin engineering—that may help reduce these painful and expensive complications. The team demonstrated improved bone formation using implants with micro-pillars topography that induces cell nuclei deformation and facilitates the differentiation of marrow-derived stem cells into bone-forming cells.

NEW CATALYST TRANSFORMS CARBON DIOXIDE INTO SUSTAINABLE BYPRODUCT

Northwestern researchers have worked with an international team of collaborators to create acetic acid out of carbon monoxide derived from captured carbon. Using a novel catalyst created in the lab of Professor Ted Sargent, this innovation could spur new interest in carbon capture and storage.

"Carbon capture is feasible today from a technical point of view, but not yet from an economic point of view," Sargent says. "By using electrochemistry to convert captured carbon into products with established markets, we provide new pathways to improving these economics, as well as a more sustainable source for the industrial chemicals that we still need."

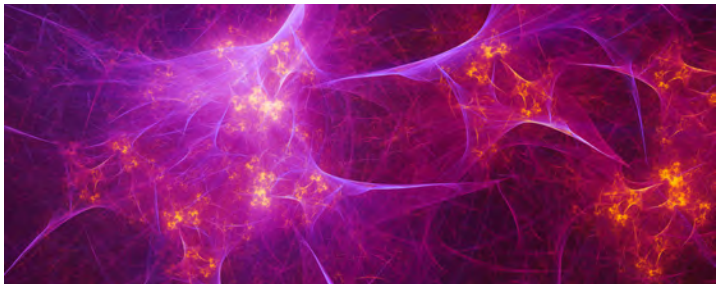
Though acetic acid may be most familiar as the key component in household vinegar, about 90 percent of it is used in the manufacture of paints, coatings, adhesives, and other products. Currently, the acetic acid produced at this scale is derived primarily from methanol, which comes from fossil fuels.

€5

Number of world-renowned scientists who gave talks on the latest research at the 2023 Symposium on Physical Genomics

$167,928

Amount a student group received from NASA's 2023 Breakthrough, Innovative, and Game-Changing (BIG) Idea Challenge: Lunar Forge



Harnessing Biological Sensors Outside the Cell

Work from Professor Neha Kamat could lead to novel biosensors, potentially supporting breakthroughs in diagnostics and environmental monitoring.

She and her team harnessed a major bacterial sensory system called two-component systems and recapitulated its function outside the cell. While other teams have done similar work using cellular parts to build sensors, researchers have faced difficulty using membrane proteins, sensors that sit in the cell membranes of all organisms.

Kamat's research illustrates a way to use membrane proteins outside the cell to design both biological sensors that can detect a signal of interest and genetic circuits that convert a detection event into the synthesis of a specific RNA or protein molecule.

"Our work illustrates a way to use membrane proteins outside of the cell and importantly, in a way that allows for signal transduction to gene expression systems."

NEHA KAMAT Associate Professor of Biomedical Engineering

"PEROVSKITE SOLAR CELLS OFFER NEW PATHWAYS TO OVERCOME SOME OF THE EFFICIENCY LIMITATIONS OF SILICON-BASED TECHNOLOGY, WHICH IS THE INDUSTRIAL STANDARD TODAY."

TED SARGENT
Professor of Electrical and Computer Engineering

Improved Stability Could Help Perovskite Solar Cells Compete with Silicon

Traditional solar cells made of high-purity silicon wafers, which are energy-intensive to produce, can only absorb certain parts of the solar spectrum.

In contrast, perovskite solar cells made of layers of nanoscale crystals are more amenable to low-cost manufacturing methods. By adjusting the size and composition of the crystals, researchers can also "tune" the wavelengths of light they absorb.

It is also possible to deposit perovskite layers on top of each other, or even on top of silicon solar cells, enabling them to use more of the solar spectrum and further increase their efficiency.

Over the past few years, advances from the lab of Professor Ted Sargent have brought the efficiency of perovskite solar cells to within the same range as that achievable with silicon. Yet, silicon solar cells still have an advantage in some areas, including stability.

Now, Sargent and an international team of Northwestern Engineering and University of Toronto researchers have closed that gap by creating a perovskite solar cell that can stand up to high temperatures for more than 1,500 hours—a key milestone as this emerging technology moves closer to commercial application.

The team members used their expertise in materials discovery, spectroscopy, and device fabrication to design and characterize a new coating for the surface of the perovskites. That data showed that the coating, made with fluorinated ammonium ligands, enhances the stability of the overall cell.

What Does a "Twinkling" Star Sound Like?

Stars appear to twinkle because Earth's atmosphere bends starlight as it travels to the planet. But stars also have an innate twinkle—caused by waves of gas on their surfaces—imperceptible to Earth-bound telescopes.

A Northwestern-led team of researchers has developed the first 3D simulations of energy rippling from a massive star's core to its outer surface. Using these models, the researchers determined how much stars should innately twinkle.

The team also converted these rippling waves of gas into sound waves, enabling listeners to hear both how the interiors of stars and the twinkling should sound.

"Motions in the cores of stars launch waves like those on the ocean," says postdoctoral fellow Evan Anders, who led the study with Professor Daniel Lecoanet. "When the waves arrive at the star's surface, they make it twinkle in a way that astronomers may be able to observe. For the first time, we have developed computer models which allow us to determine how much a star should twinkle as a result of these waves."

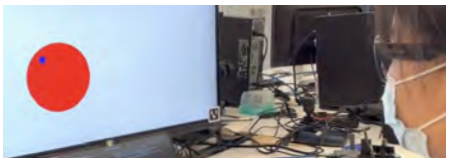
Moving Closer to Using Earth's Power Efficiently

A recent paper by Professor Chris Wolverton could help scientists come closer to harnessing the earth's natural heat. Wolverton and his team proposed a model that unifies different kinds of heat carriers to model the lower limit of lattice thermal conductivity and applies it to thousands of inorganic compounds.

Lattice thermal conductivity, a fundamental property of materials, plays a vital role in thermal energy conversion and management. Understanding its lower limit—known as its minimum thermal conductivity—helps scientists understand a material's capabilities. The team built a machine-learning model that allows scientists to search efficiently for new materials that have low thermal conductivity, which could potentially change the balance of how much energy is used and how much is wasted.

"IF SUCCESSFUL, WE WOULD HAVE A FIRST EXAMPLE OF SPECIFICATIONS RELATED TO THIS HUMAN-COMPUTER INTERACTION SYSTEM. THE LONG-TERM GOAL IS TO EMPOWER STAKEHOLDERS, LIKE END-USERS, THEIR CAREGIVERS, AND THEIR CLINICIANS, TO DESIGN INTERFACES THAT ALLOW FOR INTERACTION WITH ASSISTIVE TECHNOLOGY."

BRENNA ARGALL Associate Professor of Computer Science and Mechanical Engineering



STUDY FINDS EYE GAZE SIGNALS PROVIDE KEY ANSWERS IN ASSISTIVE DEVICE CONTROL

In the final stages of amyotrophic lateral sclerosis (ALS), many people can't move their arms or legs, but they can control their eyes. Using eye-tracking technology to gather data on eye-gaze signals, a Northwestern research team has concluded it's likely that assistive devices can be designed to help people with ALS move around more easily.

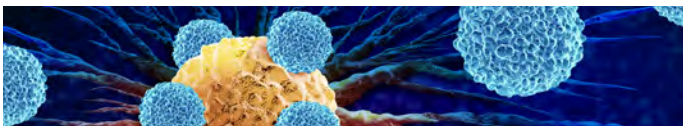
The team, which included Professors Brenna Argall and Todd Murphey, will next use these findings to produce formal guidelines for eye-gaze-based devices.

$3 MILLION

National Science Foundation grant given to an interdisciplinary team to provide access to at-home water tests for lead, copper, and PFAS

90 PERCENT

Cell preservation rate of a new localized electroporation device (LEPD) made by Horacio Espinosa for cellular engineering



UNCOVERING WHY SOME CELLS BECOME RESISTANT TO ANTICANCER THERAPIES

A research team led by scientists from Northwestern and the University of Pennsylvania has created a new synthetic biology approach, a "QR code for cancer cells," to follow tumor cells over time. Their study found meaningful differences in why a cancer cell dies or survives in response to anticancer therapies.

Remarkably, the fate of cancer cells after months of therapy is predictable based on seemingly small, yet important, differences apparent even before treatment begins. The researchers also discovered the reason is not genetics, contrary to what some in the field believe.

The study, led by Assistant Professor Yogesh Goyal, outlined the new technology platform that developed a QR code for each of millions of cells for scientists to find and use later. The code directs researchers to a genome-wide molecular makeup of these cells and provides information about how they've reacted to treatment.

Improving the Tiniest Elements of Quantum Communication

The goal of quantum communication is to send information quickly and securely through encrypted channels. Improving that process requires delicate work to control how light is released by single-photon emitters.

These emitters can be hosted in two-dimensional (2D) materials, and a team led by Professor Mark Hersam found that changing how the surface of these materials is chemically treated can influence the purity of the light that is emitted.

Single-photon emitters, which create exactly one quantum energy packet of light at a time, are produced in 2D semiconductors such as monolayer tungsten diselenide by mechanically straining the material. Current methods, however, result in irregular mechanical strains and cause the single-photon emission spectrum to become complicated and irreproducible.

Hersam and his colleagues came up with a novel "chemomechanical" method to improve the single-photon purity of quantum emitters by combining localized mechanical strain with chemical surface functionalization. This gives researchers more control over how the single-photon emitters produce light.

"We anticipate that this work will advance the development of more efficient quantum communication protocols and quantum computing devices in addition to impacting the broader fields of nanophotonics and 2D materials research." **MARK HERSAM** Walter P. Murphy Professor of Materials Science and Engineering

Dissolving Cardiac Device Monitors, Treats Heart Disease

One-third of heart disease deaths result from complications shortly following a traumatic heart-related event.

To help prevent those deaths, researchers at Northwestern and the George Washington universities—including Professor Igor Efimov—have developed a new device to monitor and treat heart disease and dysfunction in the days, weeks, or months following such events. After the device is no longer needed, it harmlessly dissolves inside the body.

5 DAYS

Length of the 22nd annual ACM Interaction Design and Children Conference held at Northwestern, showcasing the latest research and technologies in inclusive child-centered design, learning, and interaction

$20,000

Grant received by Northwestern students who are designing a pen for Parkinson's patients

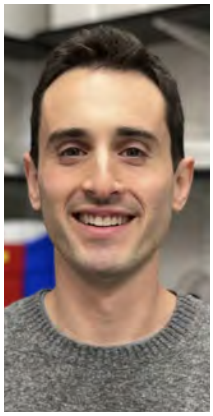
NEW THERAPY HARNESSES PATIENTS' BLOOD CELLS TO FIGHT TUMORS

Adoptive cell therapy (ACT) is a promising immunotherapy tool to help treat advanced melanoma. The therapy, which harnesses immune cells collected from the patient's own tumors, could provide a new treatment option to cancer patients, potentially bypassing radiation therapies and harsh chemotherapy drugs.

For the first time, Northwestern scientists, led by Professor Shana Kelley, discovered it is possible to isolate a tumor's attack cells noninvasively from blood, rather than from tumors. The finding opens the door for ACT to treat harder-to-reach cancer types and makes it a more viable option for hospitals. Kelley has spun out the new technology into a health tech startup that will petition the US Food and Drug Administration to move the platform into clinical trials.

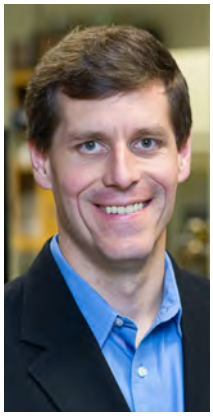
Guillermo Ameer

Danielle Tullman-Ercek



Sam Kriegman

Jian Cao



Mark Hersam

Xiao Wang

Shana Kelley

Muzhou Wang

Niall Mangan

Brenna Argall

Julius Lucks

Laurence Marks

Faculty Awards

Three Faculty Members Elected to American Academy of Arts and Sciences

Guillermo Ameer, Jian Cao, and Shana Kelley were elected members of the AAAS, one of the nation's oldest and most prestigious honorary societies.

Two Faculty Members Inducted into AIMBE College of Fellows

Brenna Argall and Danielle Tullman-Ercek are among the 140 members of the American Institute for Medical and Biological Engineering's College of Fellows Class of 2023, who represent the top 2 percent of medical and biological engineers.

Mark Hersam Awarded Ver Steeg Fellowship

The award recognizes tenured Northwestern faculty whose work enhances the national and international reputation of the University.

Muzhou Wang Receives Camille Dreyfus Teacher-Scholar Award

The prestigious national award honors young faculty members in the chemical sciences who demonstrate leadership in research and education.

Julius Lucks Named Guggenheim Fellow

Lucks earned one of 171 fellowships awarded this year from a pool of nearly 2,500 applicants.

Sam Kriegman Named Schmidt Futures AI2050 Early Career Fellow

With the fellowship, Kriegman and his team will investigate how to speed up the evolution of smarter AI systems.

Xiao Wang Earns National Science Foundation CAREER Award

With the funding, Wang aims to design efficient, robust, and scalable protocols and software infrastructures to push the practical application of secure multiparty computation.

Niall Mangan Receives US Department of Energy Early Career Research Program Award

Mangan will use the award to advance research in semiautomated methods to characterize energy systems from complex data.

Laurence Marks Awarded Fulbright US Scholar Fellowship

Marks will take his research to Australia, continuing his study of how static electricity forms.

ENVIRONMENTAL ENTREPRENEURS

NORTHWESTERN ENGINEERING FACULTY MEMBERS ARE TAKING THEIR SUSTAINABLE INNOVATIONS OUT OF THE LAB AND INTO INDUSTRY TO HELP MITIGATE THE EFFECTS OF CLIMATE CHANGE AND POLLUTION.

Rapidly advancing technology has given much of the world a better quality of life. People live longer, healthier lives. They connect and collaborate with others around the world. They have access to the energy needed to power their homes, businesses, and vehicles. Yet, these same advances have also led to some of Earth's greatest environmental problems: climate change, pollution, and contaminated water.

Many Northwestern Engineering faculty have channeled their problem-solving mindset toward sustainable solutions for some of the crises that threaten society most. By founding startups to commercialize their ideas, they can move their solutions beyond the lab and help turn the tide on environmental degradation. ▸▸▸

OPERA BIOSCIENCE

Creating affordable, sustainable proteins for meat alternatives, biofuels, and biomaterials

Founded by chemical and biological engineering professor Danielle Tullman-Ercek, startup Opera Bioscience has pioneered a biomanufacturing platform that produces affordable, high-purity proteins.

This new platform reduces the cost of goods for making meat alternatives, biofuels, and biomaterials and could lead to more sustainable replacements for environmentally costly processes like animal factory farming and oil drilling.

When Tullman-Ercek joined Northwestern Engineering in 2016, she was directed to the Innovation and New Ventures Office (INVO), where she learned that her research on protein secretion—the basis for this new platform—might be worth patenting.

Soon after connecting with INVO and filing her first patent application, Tullman-Ercek founded Opera Bioscience, an acronym that stands for Optimized Protein Expression Research and Applications.

INVO connected Tullman-Ercek with Equalize, a program out of Washington University in St. Louis for women academic inventors. She participated in the program's 2022 pitch competition and was named overall winner in the MedTech category.

Today, the majority woman-owned and veteran-run startup has moved into Northwestern's Querrey InQbation Lab in downtown Evanston, where the company continues to create affordable, high-purity proteins for commercial applications.

"There's so much we're doing in the lab now that we never would've thought to do without these conversations with the business side of the world—they ask questions that we had not asked before," says Tullman-Ercek, who also serves as codirector of Northwestern's Center for Synthetic Biology.

VOLEXION

Moving society toward battery-powered transportation of all types

One day, batteries could power the semi-trucks and freight trains that carry tons of cargo long distances and airplanes that circumnavigate the globe.

To help realize this future, Mark Hersam, chair and Walter P. Murphy Professor of Materials Science and Engineering, has focused on improving the cathode of lithium-ion batteries. The cathode holds the lithium ions when discharged, but the surface of the cathode degrades following repeating charging and discharging cycles, which compromises the ability of the battery to store and deliver energy.

By encapsulating the cathode with a protective layer of graphene, Hersam and his team suppress the degradation that causes many lithium-ion batteries to fade, fail, and even catch fire. The graphene coating also results in a higher-energy battery that extends the driving range for electric vehicles, advances safety, improves sustainability, and lowers cost.

Hersam spun out his invention into tech startup Volexion in 2018. The next year, Volexion received the US Department of Energy's Ten at Ten Award, which honored 10 extraordinary renewable energy technologies. Then last fall, Volexion became one of the first startups to take up residence in Northwestern's Querrey InQbation Lab, where the company has access to even more of the University's world-class expertise and resources.

Volexion is working to scale up its new technology so it can engage potential customers, move into the marketplace, and eventually lower carbon emissions. The InQbation Lab is assisting the company in doing just that.

"Taking our technology to market and ultimately incorporating it into devices and vehicles that everyone uses will have direct impact on society," Hersam says.

1

STEMLOOP

Enabling easy, affordable water testing to improve lives worldwide

Billions of people live in areas where the water supply is contaminated. Many, if not most, lack a practical, affordable means to determine whether their water is safe to use.

To help test water in these areas, chemical and biological engineering professor Julius Lucks and his collaborators developed an accurate, low-cost, and easy-to-use biosensor device to detect water contaminants. The cell-free system emits light when mixed with target compounds, including fluoride and lead.

To commercialize the technology, Lucks and the team launched startup Stemloop in 2019. Since then, Lucks has field-tested the technology in Kenya, showing the potential for finding harmful contaminants without sending samples to labs that have specialized equipment.

Now, Stemloop is focusing on launching its first product: a home test to detect lead in drinking water. The company is also part of a team that was awarded a National Science Foundation grant to provide access to at-home water tests for lead, copper, and per- and polyfluoroalkyl substances, also known as "forever chemicals." The team, which combines experts from Northwestern's Center for Synthetic Biology, Roberta Buffett Institute for Global Affairs, and Institute for Policy Research, will measure the tests' impact and use the knowledge gained to improve people's daily lives.

"It's clear that we need to enable people with information to make important, sometimes lifesaving decisions," says Lucks, who is also codirector of the Center for Synthetic Biology. "People need at-home tests because they need that information quickly and regularly. There are many cases where water quality needs to be measured routinely. It's not a one-time thing because contamination levels can change over time."

1 ROSALIND, the handheld platform that uses cell-free biosensors and a one-drop water sample to provide an easy-to-read positive or negative result for contaminants.

QUERREY INQBATION LAB

Transforming Northwestern innovation into commercial success and economic growth

Many of the companies featured in this article are residents of Northwestern's new multimillion-dollar technology accelerator, the Querrey InQbation Lab. The InQbation Lab provides a home for Northwestern's highly entrepreneurial faculty to commercialize their scientific discoveries and bring economic growth and opportunities to the Evanston and Chicago communities.

Located at 1801 Maple Avenue in downtown Evanston, the Querrey InQbation Lab opened in 2022 and was named in honor of Kimberly K. Querrey ('22, '23 P), chair of the Innovation and Entrepreneurship Committee of Northwestern's Board of Trustees.

Querrey was so committed to making the incubator a reality that she personally made a $25 million gift to Northwestern to advance innovation and entrepreneurship. The Illinois Department of Commerce and Economic Opportunity provided a $3 million grant to support the first phase of renovations at the Querrey InQbation Lab. The Illinois General Assembly also appropriated $50 million for further expansion of the project as part of the state's 2022 capital budget.

In addition to space for faculty startups, the lab offers fellowships, residencies, scholar programs, a mentor network, and seminars and workshops for faculty and students.

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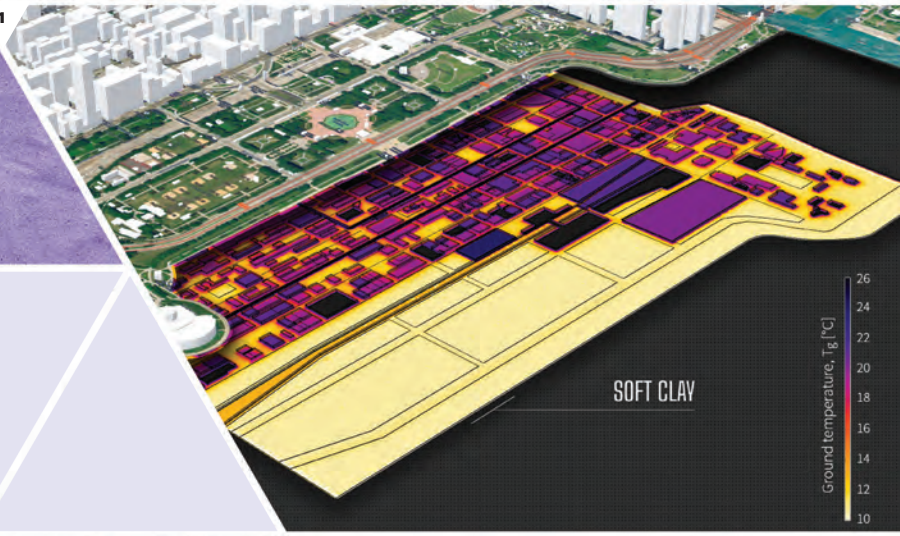

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Tour the InQbation Lab
View the Querrey InQbation Lab's startup labs, foundries, and community spaces.

ENERDRAPE

Turning underground structures into renewable energy sources

Underground temperatures continue to rise because of the heat that diffuses from buildings and subsurface transportation—a phenomenon that scientists refer to as "underground climate change." This can cause building foundations and the surrounding ground to move excessively and even crack, which ultimately will affect a structure's long-term operational performance and durability.

Alessandro Rotta Loria, Louis Berger Assistant Professor of Civil and Environmental Engineering, studied the effects of these deformations using more than 150 temperature sensors across Chicago's downtown area. He then built a 3D computer model to simulate how the ground deforms in response to these increasing temperatures, showing that the city is slowly sinking.

Not content just to measure the effects of underground climate change, Rotta Loria and his collaborators have also devised a way to put that extra heat to work. He and a team from the Swiss Federal Institute of Technology in Lausanne have developed prefabricated geothermal panels that harness untapped renewable geothermal and waste thermal energy from underground. These thin panels absorb heat from underground spaces (like parking garages or tunnels) and the surrounding ground, then use that energy with electric heat pumps to meet the thermal energy requirements of buildings and infrastructures.

The solution has been commercialized by the cleantech spin-off Enerdrape, founded in 2021. Rotta Loria, a cofounder, serves as CTO of the company, which recently installed 200 panels in a parking garage near Lausanne as a pilot project and will soon deploy another pilot installation in Chicago.

"These panels essentially turn underground infrastructures into renewable energy sources," Rotta Loria says. "Our panels offer a way to transition to efficient renewable energy systems in existing urban environments."

MFNS TECH

Cleaning up oil spills at lower cost and higher speed with less negative impact on the environment

Thousands of oil spills happen each year, coating wildlife with residue and releasing toxic compounds that can have lasting effects on the ecosystem.

In 2020, Vinayak Dravid, Abraham Harris Professor of Materials Science and Engineering, and his senior group member Vikas Nandwana developed a highly porous sponge that selectively soaks up oil in water. The sponge harnesses the power of an oleophilic hydrophobic multifunctional coating developed by Dravid and his group, which can selectively sequester oil and oil-related complexes. Able to absorb more than 30 times its weight in oil, the sponge could be used to clean up oil spills inexpensively and efficiently without harming marine life.

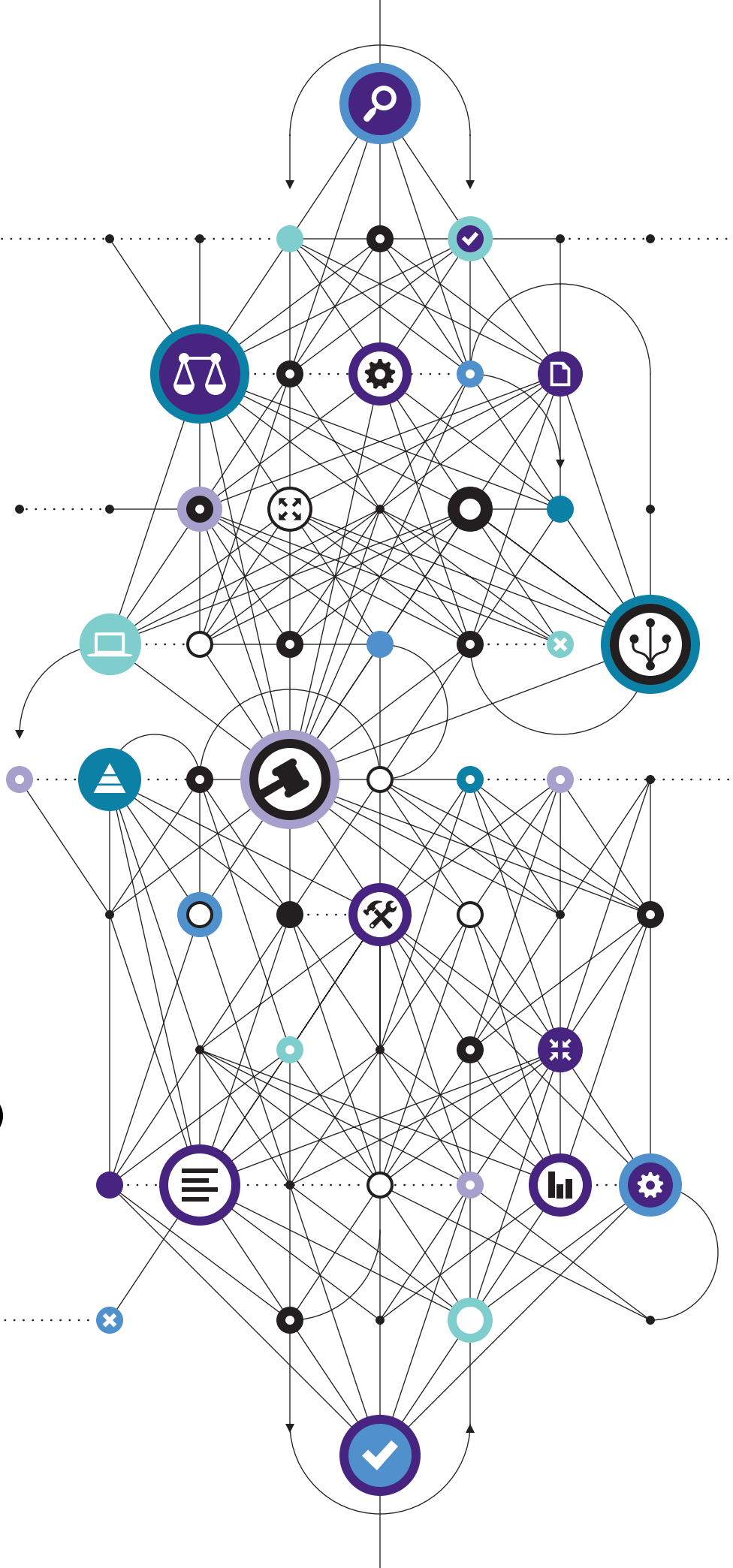
To commercialize the research, Dravid and Nandwana launched the startup MFNS Tech, which has used the sponge's patented nanostructure coating to develop products that can help businesses and communities clean up oil and filter water to remove other pollutants, like factory runoff. Earlier this year, the company secured seed investment to develop more products based on the coating.

"Although many oil spills are small and may not make the evening news, they are still profoundly invasive to the ecosystem and surrounding community," Dravid says. "Our sponge can remediate these spills in a more economic, efficient, and eco-friendly manner than any of the current state-of-the-art solutions."

1 Ground temperatures measured in the soft clay layer beneath the Chicago Loop. Credit: Alessandro Rotta Loria/Northwestern University

2 The highly porous sponge developed by Professor Vinayak Dravid is coated with an ultrathin layer of nanoparticles that helps it selectively soak up oil.

AI and the Law.



NORTHWESTERN ENGINEERING STUDENTS AND FACULTY EXPLORE THE POTENTIAL BENEFITS—AND RISKS—OF USING GENERATIVE ARTIFICIAL INTELLIGENCE IN LEGAL SERVICES.

The Jury's Still Out.

The transformative and disruptive possibilities of generative artificial intelligence (AI) have alternately captivated, alarmed, and entertained us.

In the form of large language models (LLMs)—such as OpenAI's ChatGPT and Google's Bard—generative AI has wowed millions with its ability to seamlessly mimic human speech and language, transforming our understanding of and relationship with traditional technical, creative, and professional workflows.

In law and legal services, LLMs could be a game-changer. The industry is overwhelmed by time-consuming, traditionally manual tasks, such as conducting research; drafting, reviewing, and revising legal memos, briefs, and contracts; and identifying and summarizing relevant statutes, regulations, and case law. With systems that leverage generative AI, these tasks could be completed in minutes.

In fact, a March 2023 LexisNexis survey found that 39 percent of US attorneys and 46 percent of law students believe generative AI tools will increase their efficiency. A majority of respondents suspect the technology will fundamentally revolutionize the entire practice of law.

Yet, in a field driven by human analysis and reasoning, with stakes as high as a defendant's innocence or guilt under the rule of law, these technologies pose more questions than answers. What are the limits of generative AI? What responsibility do legal professionals have to understand these technologies?

Northwestern engineers are collaborating with faculty at the Pritzker School of Law to explore these questions—with a focus on taking the right actions to pave the way for the future.

"What I worry most about with regard to generative systems and the law right now is a misunderstanding: If I think that a device is an information system or is a repository of fact, then I will treat it that way. But if it's not, then I will trust it to give me the right information, and it won't."

KRISTIAN HAMMOND Bill and Cathy Osborn Professor of Computer Science

THE LIMITS OF CHATGPT

At issue is what LLMs like OpenAI's GPT-4 can and cannot do. They can use deep learning to predict language and produce conversational text from a user prompt. They can also respond to a question with authoritative language that might have no connection to ground truth.

The McCormick School of Engineering's Kristian Hammond notes that ChatGPT's remarkable promise as a pattern-matching statistical tool has overshadowed this crucial shortcoming, leading to unrealistic expectations over the technology's potential usefulness in the legal space.

"People trust it to tell the truth, when in fact, these systems were never designed to tell the truth. They were designed to be fluent. And it turns out, if you're fluent, sometimes you tell the truth because you know how words connect to each other," says Hammond, Bill and Cathy Osborn Professor of Computer Science.

"What I worry most about with regard to generative systems and the law right now is a misunderstanding: If I think that a device is an information system or is a repository of fact, then I will treat it that way. But if it's not, then I will trust it to give me the right information, and it won't."

Generative AI products like ChatGPT are also only trained on publicly available legal databases, which inherently limits their knowledge, providing only a small part of relevant data for specific case law.

"Generative AI can't reliably do the things involved in the bare minimum of good legal analysis and writing: accurately laying out the facts of the case, accurately describing the law that applies to the case, and applying that law to those facts to come to a conclusion," says Joseph Blass (JD, PhD '23). "Large language modules are not capable of critical thinking, and legal reasoning requires critical thinking."

Blass currently serves as a judicial clerk with the Honorable Joshua Deahl, District of Columbia Court of Appeals. He was advised at Northwestern by Ken Forbus, Walter P. Murphy Professor of Computer Science.

Those in the legal sector who use LLMs without considering these issues face consequences. In June, sanctions were imposed on two New York attorneys who filed a legal brief containing six fictitious case citations generated by ChatGPT, underscoring the need for rigorous scrutiny of the outputs of computational systems.

"As lawyers, we're required to know the benefits and the risks of the technology we use," says Dan Linna, senior lecturer at Northwestern Engineering and the Pritzker School of Law. "Lawyers need a functional understanding of these tools, including so that they can ask good questions of the developers about things like the training data and how AI systems have been validated and how they will fail."

Linna notes this doesn't mean that those in law cannot use LLMs to their advantage—they just must be informed of its benefits and risks. He says that even ChatGPT can assist with certain tasks, such as improving the clarity and persuasiveness of writing, and legal technology startups and traditional information providers are building reliable generative AI tools for a range of tasks, from legal research to assisting with contract drafting.

HELPING LEGAL PROFESSIONALS NAVIGATE THE RISKS

To help legal professionals navigate these issues and understand how ChatGPT and generative AI could change legal services, Northwestern Engineering and the Pritzker School of Law held an interactive executive education class in April.

Led by Linna and Hammond, the course addressed several topics, including developing a fundamental understanding of how ChatGPT and similar LLMs work and assessing the value of leveraging generative tools. Thirty-three legal professionals attended—representing law firm leadership, consulting companies, and legal services providers.

"People closest to the work need to understand these tools and experiment responsibly to learn how they can use them to provide greater value to the clients they serve," Linna says.

That value could include LLMs that quickly generate or revise text in legal memos or that extract and summarize pertinent information from contracts and briefs. Attendees also learned how AI-based chatbots powered by specialized knowledge bases could quickly answer legal research questions and foster brainstorming. These use cases, according to Hammond, reinforce generative AI's potential as a supporting tool for legal professionals.

"If the attendees thought, 'We're going to get ourselves a language model, and we're going to take all of our contracts and train it'—it's just not going to work because it doesn't know how to reason like a lawyer," Hammond says. "There's this idea that that you can make these systems better by just showing them more and more documents. But you don't teach someone to be a lawyer by having them read a whole bunch of contracts or a whole bunch of regulations. They've got to reason better than that."

"As generative AI continues to evolve, lawyers and computer scientists need to collaborate to understand its possibilities and risks," says Hari Osofsky, dean and Myra and James Bradwell Professor of Law at the Pritzker School of Law. "We're excited to partner with the McCormick School of Engineering at the interface of law and legal practice with emerging technology, and I am grateful to Professors Linna and Professor Hammond for their leadership and innovative contributions."

PROMOTING STUDENT COLLABORATION TO CREATE BEST PRACTICES

A better understanding of the value and limits of generative AI in the law is also being fostered in Northwestern Engineering classrooms, where students are learning how to best use LLMs. Last winter, Hammond and Linna cotaught the Innovation Lab: Building Technologies for the Law course, which brought computer science undergraduate and graduate students together with law students to develop and deploy client-focused technology solutions.

Working with clients ranging from Adobe and Thomson Reuters to law firms and legal aid organizations, eight interdisciplinary teams applied computational technologies, including ChatGPT and other LLMs, to augment and automate a range of legal tasks, including drafting and reviewing contracts and providing legal guidance to businesses and individuals.

"The most important lesson we teach the students is: don't start with the technology," Linna says. "One of the ways we can contribute value for our project partners is to make sure we deeply understand the crux of the problem. Our clients may have a particular idea of what the solution is, but maybe there's another pathway to it."

One student team partnered with Berkeley Research Group to develop Contract Genie, which leverages ChatGPT to augment the drafting of compliant, industry-standard employment contracts within minutes. Another group collaborated with the Law Center for Better Housing to improve the natural language taxonomy of the LCBH Rentervention chatbot, a free resource designed to help Illinois renters diagnose their legal housing issues, understand their rights, and explore solutions.

"Computer scientists can be very insulated with code-specific problems or algorithmic abstractions," says Siddharth Saha, an undergraduate student pursuing a degree in computer science from Northwestern Engineering and another in mathematics from Northwestern's Weinberg College of Arts and Sciences. "Seeing problems faced by real people up close can provide the most clarity on how to develop the best kinds of solutions. Effective channels of communications between lawyers and computer scientists are becoming crucial in a legal setting increasingly influenced by big data."

FINDING THE RIGHT PATH FORWARD

As with any landmark technology, the hype around LLMs may outpace their capabilities. Yet, as short- and long-term questions swirl around how generative AI will change the legal field, Linna advises leaders in the space to remain focused on taking action.

"We're making decisions right now that will play a huge role in determining how AI is used to make society better by improving the law, the courts, the delivery of legal services, and access to justice. So, let's get started," Linna says. "We must be proactive. Lawyers and legal industry professionals need to collaborate with others to move the profession forward. There's so much positive action that can be taken. If we want to have a seat at the table, now is the time to act."

MICHELLE MOHNEY

"People closest to the work need to understand these tools and experiment responsibly to learn how they can use them to provide greater value to the clients they serve."

DAN LINNA Senior Lecturer, Northwestern Engineering and Pritzker School of Law

"I look forward to helping people liberate their creativity and enable their innovation to achieve their goals. It doesn't get more rewarding than knowing you've helped people succeed. To do that here with this incredible faculty, staff, and students—it's frankly the opportunity of a lifetime."

INTRODUCING DEAN CHRISTOPHER SCHUH

Read the online version of this story to learn more about Dean Schuh's research and interests.

Christopher Schuh (PhD '01) has always had an affinity for the Midwest. A native of northern Wisconsin, he earned his undergraduate degree from the University of Illinois Urbana-Champaign. Soon after, he moved to Evanston and joined Northwestern Engineering's doctoral program in materials science.

Schuh's journey eventually brought him to the East Coast, where he built a renowned career at the Massachusetts Institute of Technology (MIT). There, he conducted trailblazing research in metallurgy, launched startup companies, educated hundreds of engineering students, and led the university's materials science department for almost a decade.

Today, Schuh has returned to the familiar halls of the Technological Institute—but not just as an alumnus. In June, he was named dean of the McCormick School of Engineering.

As he embarks on his new role, Schuh took time to discuss his engineering background, the importance of research translation, his Northwestern roots, and what excites him most about being dean.

How did you become interested in engineering? I've always been drawn to mathematical ways of thinking and data-driven decision-making. I enjoy having mathematical certainty about what I'm doing, and engineering is a natural place where those skills are useful. I also enjoy engineering because it integrates vertically, from fundamental science all the way to products—it's integral at many levels of the processes that drive innovation.

I love scientific discovery and thinking deeply about how things work, working with microscopes, doing computer simulations. If you understand how things work, then to me the next logical step is to start tinkering and making them work in different ways. That connection between how things work and making things work is what engineering is all about.

Finally, and more broadly, I've always found engineering interesting because it is goal driven. There's always a story behind the problems engineers are trying to solve, and it's often concerning human beings. Engineering is a very humanist endeavor. I like the idea that what I do contributes to the betterment of humankind.

Most recently, you were chair of the Department of Materials Science and Engineering at MIT. What's your favorite memory from your time there? I'm most proud of the connections I made with students. After I became head of the materials science department in 2010, some of my undergraduate students got together and printed T-shirts with a photoshopped image of me wearing the Iron Man suit. I felt a sense of community recognition, that they cared and supported me. That was very important to me.

Why did you pick Northwestern to earn your PhD in materials science? How did your experience here shape your career? For me, graduate school was about achieving a greater depth of understanding, both on the scientific side and also on the marketplace side.

Northwestern felt unique in that regard. McCormick's materials science program was incredible, but I was also able to take courses in entrepreneurship at the Kellogg School of Management while I was here, as well as complete a minor in applied mathematics. This approach helped me vertically align my education and prepare me for the rest of my career. Not only did I get a deep education in materials science research, I also explored mathematical modeling and started to think about entrepreneurship. Northwestern is where all of that happened for me.

You've written that it's important for engineers to balance scientific discovery with an understanding of the marketplace. Why do you think research translation—moving technologies from the lab into industry—is so important, especially today? Engineers are the fulcrum between the research lab and the marketplace. And the marketplace represents humanity. As the planet matures, the needs of humanity become bigger and more complicated and interconnected—from the environment and sustainability to AI to resource management to health. The solutions to these challenges are rooted in scientific research, and engineers serve as the bridge between these two worlds. Not every single engineer needs to connect those worlds—some will focus on fundamental research, others will work more with products—but as a field, this is our function.

Do you have a favorite memory from your time as a PhD student? Early on in my PhD, in my adviser David Dunand's lab in Cook Hall, I had a mountain of data on my desk, and I was practicing my new skills in mathematical modeling to try and understand it. There was a moment where the model and the data overlapped, and one explained the other. I felt victorious elation in that moment as the data and my own deep thinking literally came together to explain something for me.

Why did you want to become dean of Northwestern Engineering? What excites you the most about stepping into this position at Northwestern? Being the dean of engineering is a great role to be both technically oriented and people oriented at the same time. As I mentioned, I enjoy the concepts of vertical integration and of the fulcrum between fundamentals and markets. I like having a foot in both of those camps, and leaders in science and engineering work exactly in this space.

I look forward to helping people liberate their creativity and enable their innovation to achieve their goals. It doesn't get more rewarding than knowing you've helped people succeed. To do that here with this incredible faculty, staff, and students—it's frankly the opportunity of a lifetime.

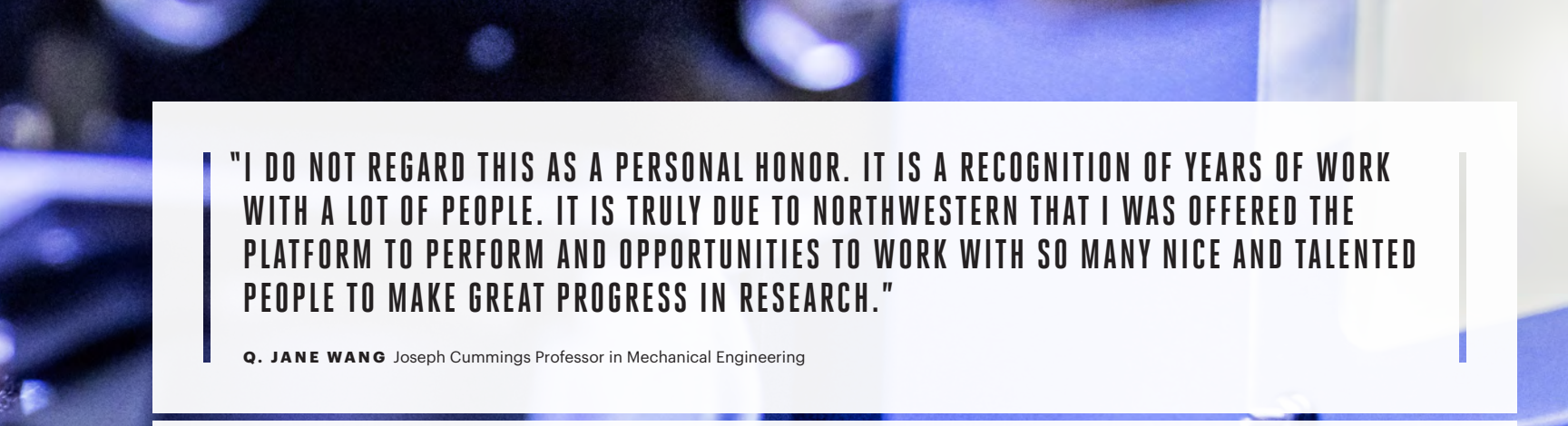
What are you most looking forward to during your first academic year as dean? I'm excited to meet as many people as I can. I want to learn and listen. By the end of this year, I'm going to have a mountain of data, and I'm looking forward to sorting through it all and beginning to piece together a collective vision of where McCormick should go from here.

ALEX GERAGE

Photography by Jason Brown and Matthew Allen

WORKING AT THE FOREFRONT OF TRIBOLOGY, Q. JANE WANG AND HER TEAM CONTINUE TO ADVANCE NEXT-GENERATION TECHNOLOGY.

SMOOTHING THE FUTURE



> "I DO NOT REGARD THIS AS A PERSONAL HONOR. IT IS A RECOGNITION OF YEARS OF WORK WITH A LOT OF PEOPLE. IT IS TRULY DUE TO NORTHWESTERN THAT I WAS OFFERED THE PLATFORM TO PERFORM AND OPPORTUNITIES TO WORK WITH SO MANY NICE AND TALENTED PEOPLE TO MAKE GREAT PROGRESS IN RESEARCH."
>
> **Q. JANE WANG** Joseph Cummings Professor in Mechanical Engineering

The roots of tribology—the study of friction and lubrication between surfaces in contact and relative motion—go hand in hand with the industrial revolution and engineering development.

But as new technologies like electric vehicles (EVs) raise both novel and longstanding questions, Northwestern Engineering Professor Q. Jane Wang is working at the forefront of the discipline's future. Her latest tool? Artificial intelligence (AI).

"Tribology is a challenging thing," she says. "There are lots of places where the basic theories are missing. If we can use AI to help build fundamental equations and develop fundamental theories, that would be helpful, because tribology is dealing with complicated things."

Wang, Joseph Cummings Professor in Mechanical Engineering, has long been a pioneer in the field. In February 2023, she was elected to the National Academy of Engineering (NAE) for "contributions to computational tribology in industrial applications." Her work has led to better-performing and more reliable engines, batteries, and lubricants used across industries.

Now, Wang and her lab associates are working to contribute further by finding the best avenues for putting AI to use. As executive director of Northwestern's Center for Surface Engineering and Tribology (CSET)—which addresses critical problems related to surface failure that affect key components in advanced engines, manufacturing equipment, bearings, batteries, and biomechanical systems—Wang is working on developing a framework to unify numerous segments of tribology.

"I think AI can help us go deeper into the science and build more connected, robust models," she says. "You can see many things happening at the same points, but it is difficult to know exactly what is going on all together. We hope AI helps us to identify what is happening, the parameters needed to build the correct setup for phenomenon regeneration, and what will happen next. That is very important to the prevention of system failures."

SOLVING PROBLEMS VIRTUALLY

Wang's forward-thinking mindset serves her well as she investigates tribology related to EVs, which have internal systems that differ greatly from their gasoline-powered counterparts. EVs differ from traditional internal combustion vehicles in their wear mechanisms, lubrication needs, battery storage, and even cooling issues. For example, the bearings in internal combustion engines, which use regular lubrication, have no electrical current running through them. That is not the case with EVs, a difference that could result in a build-up of electrical voltage and cause problems.

"How to prevent, predict, model, and design parts to avoid those issues is one of the biggest challenges we face right now," Wang says. "We need to work on lubricants that are safe under an electrical field and will not degrade the surfaces they are protecting."

To rise to the challenge, Wang builds on her prior accomplishments, one of which is virtual tribology. Consisting of groups of model-based simulations, virtual tribology is a concept she proposed at the beginning of the century and developed in an National Science Foundation-funded Integrative Graduate Education and Research Traineeship Program at Northwestern's CSET, led by Wang and the late professor Leon Keer. That virtual system then used advanced computer modeling to simulate the interfacial interactions among critical tribological elements.

A PLATFORM TO PERFORM

Wang and her colleagues at CSET still conduct research into problems that touch many aspects of daily life. "We focus on developing computer codes for industrial applications and work with industries on individual research projects," Wang says. "So, no matter what we do, we support the application of tribology to industries."

Wang is also following in the footsteps of the late Herbert Cheng, one of the faculty members who initiated CSET and Wang's PhD adviser at Northwestern when she earned her doctorate in 1993. Reflecting on her election to NAE and the support she's received during her career, Wang says she considers the influence of Cheng and Keer, her professors, colleagues, associates, students, and collaborators, and the University as a whole as key to her success.

"I do not regard this as a personal honor. It is a recognition of years of work with a lot of people," Wang says. "It is truly due to Northwestern that I was offered the platform to perform and opportunities to work with so many nice and talented people to make great progress in research."

BRIAN SANDALOW

Photography by Matthew Allen

Transforming Our Understanding of Human Biology

Led by Professor Shana Kelley, the new Chan Zuckerberg Biohub Chicago will bring together multi-institutional, interdisciplinary researchers to better understand the biological processes that drive inflammation and disease.

More than half of all deaths in the world today are attributed to diseases driven by chronic inflammation, from cancer to stroke to heart disease to diabetes.

Northwestern Engineering's Shana Kelley is determined to better understand why.

Kelley, Neena B. Schwartz Professor of Chemistry and Biomedical Engineering, will lead and serve as president of the Chan Zuckerberg Biohub Chicago (CZ Biohub Chicago), a new research hub supported by the Chan Zuckerberg Initiative (CZI) that will develop new technologies for studying human tissues with unprecedented resolution.

Northwestern will co-lead CZ Biohub Chicago with the University of Chicago and the University of Illinois Urbana-Champaign. The hub's goal is to unite the region's best researchers to improve understanding of inflammation, potentially leading to new treatments for the inflammatory conditions that underlie disease.

CZI selected the Chicago team from a pool of 58 teams after a yearlong, highly competitive application process for a research initiative explicitly focused on measuring human biology.

"We're thrilled to be part of the Chan Zuckerberg Biohub Network, which will galvanize multidisciplinary research and drive more progress than any one of these institutions could have achieved on its own," Kelley says. "The scientific challenge we're exploring—to develop new tools to better measure tissues and gain insights into inflammation—has large engineering challenges to surmount, and is wildly, but not impossibly, ambitious—and can only be solved by interdisciplinary collaboration."

Building a national network

The Chicago site is the first expansion of the CZ Biohub Network, which launched in 2021. The network builds off the successful model of the CZ Biohub in San Francisco, launched in 2016. Located in Chicago's Fulton Market neighborhood, CZ Biohub Chicago is scheduled to open in early 2024 and include 28,000 square feet of state-of-the-art laboratories, meeting spaces, faculty-in-residence space, a biofoundry, and other sophisticated instrumentation.

"We are excited to scale this successful model of collaborative science into a larger network by welcoming the new Biohub in Chicago," CZI cofounder and co-CEO Priscilla Chan says. "This institute will embark on science to embed miniaturized sensors into tissues that will allow us to understand how healthy and diseased tissues function in unprecedented detail. This might feel like science fiction today, but we think it's realistic to achieve huge progress in the next 10 years. I look forward to the advances in science and technology that this new Biohub will spur in studying how tissues function to understand what goes wrong in disease and how to fix it."

"The scientific challenge we're exploring—to develop new tools to better measure tissues and gain insights into inflammation—has large engineering challenges to surmount, and is wildly, but not impossibly, ambitious—and can only be solved by interdisciplinary collaboration."

SHANA KELLEY
Neena B. Schwartz Professor of Chemistry and Biomedical Engineering

Using sensors to study human tissues

To explore inflammation, CZ Biohub Chicago will develop engineering technologies to make precise, molecular-level measurements of biological processes within human tissues. This work will include embedding thousands of sensors and sampling probes into human tissues. With this technology, scientists will be able to monitor molecular and cellular signals in real time, revealing how disruptions in these processes lead to inflammation and disease. By monitoring tissues in real time, the researchers aim to steer the immune system away from the "tipping points" that lead to inflammatory disorders. The work promises to broadly enable new discoveries across all areas of medicine.

"The CZ Biohub Chicago will become a global destination for performing these types of experiments," says Milan Mrksich, Henry Wade Rogers Professor of Biomedical Engineering and Northwestern's former vice president for research. "By collaborating across universities, we have assembled an absolute 'dream team' of researchers with unmatched scientific skills and talent that enabled us to compete at the highest levels. The hub will be known as a place where discoveries are made and fields are transformed—and it will better position Chicago as an environment for life science translation and entrepreneurship."

During the application process, Mrksich assembled the multi-institutional team to develop its vision for the hub. Northwestern Engineering faculty members on the planning committee included Mrksich, Kelley, Guillermo Ameer, Horacio Espinosa, and John A. Rogers.

The CZ Biohub Chicago will work with CZI teams, including its science technology team, which aspires to advance biomedical research and develop technologies to understand, observe, measure, and analyze any biological process within the human body—across spatial scales and in real time.

"The Chicago Biohub will create technologies that will transform our understanding of tissue-scale biology, revealing important information about the processes that take place in living tissues that could lead to new therapies," CZI cofounder and co-CEO Mark Zuckerberg says. "This immense scientific challenge requires bringing together researchers and technologists in new ways to accomplish great science that isn't done in conventional environments. The powerful collaborative model of the San Francisco Biohub has shown us that cross-disciplinary science leads to breakthroughs, and this integrated research model is a key part of how we'll move towards curing, preventing, or managing all disease by the end of the century."

Photography by Crystal Wiley-Brown (Shana Kelley) and Robert Buyle Photography (Building)

MINDSET *MATTERS*

RACHEL BISHOP TRANSFORMED HER DOCTORATE DEGREE IN MATERIALS SCIENCE INTO A SUCCESSFUL GLOBAL BUSINESS CAREER.

As a materials science graduate student in the late 1990s, Rachel Bishop (PhD '01) didn't find immediate success. When she performed the initial oxidation testing for her dissertation—an investigation into how changes in alloy composition would affect the oxidation of niobium-based super-alloys—Bishop's first several dozen samples disintegrated into powder in the oven.

"Catastrophic and demoralizing" is how Bishop described that experience. "I had no choice but to dig in and go to the extremes on different variables. It was the only way to get on the path toward a solution."

For ideas, Bishop tapped her doctoral adviser, Professor Greg Olson, as well as her lab mates. She continued experimenting and reflecting on results. She learned to trust her scientific instinct. Slowly, she made progress, tuning the time, temperature, and heat to increasingly precise levels. Her experiments would ultimately have implications for the performance of combustion engines in aircraft.

Bishop says her five years as a Northwestern PhD student ignited a deeper love for discovery, more intense curiosity, and, above all, earnest self-belief in her ability to unlock solutions. "A PhD is really a degree in persistence because you have to keep hitting at a specific problem and enter the unknown," she says. "It's unnerving, but necessary."

Such persistence has powered Bishop's career over the past 22 years. In her first professional role at McKinsey & Company, Bishop recalls working with a car wheel manufacturer on the cliff of bankruptcy.

Blending analysis, facts, scientific insights, and copious amounts of persistence, she presented solutions to improve the manufacturing plant's efficiency and production, which helped spark a business turnaround.

"If you can be relentless in attacking a problem, you can crack the code," she says.

Bishop carried that determined spirit into subsequent professional adventures. At Walgreens, she created new workflows and operating procedures to extract greater profitability at the chain's retail stores. At TreeHouse Foods, a leader in private-label snacks and beverages, she incorporated acquired businesses in the snack, nut, and soup categories into one cohesive, streamlined operation.

Since February 2019, Bishop has served as president of tableware for Reynolds Consumer Products, a job that includes overseeing the well-known Hefty brand. With full responsibility for business performance, Bishop directs a team of some 700 employees involved in areas such as manufacturing operations, sales, marketing, and new product development.

Among her biggest tasks today is shepherding the creation of more sustainable tableware products. The complex charge requires Bishop to dive deep into business areas like raw materials and importing, which returns Bishop to her academic roots in materials science and engineering.

"Strangely, it's the closest I've ever been to my PhD degree as a professional," she says. "But it's the mindset I developed as a PhD student that really matters. I know the solution is there, and we're going to find it."

DANIEL P. SMITH

DESIGNING WITH PURPOSE

ISAIAH ANDREW APPLIES THE RIGOR AND PROBLEM-SOLVING DISCIPLINE OF ENGINEERING TO THE WAYS GLOBAL BRANDS ENGAGE WITH CONSUMERS.

Today, Isaiah Andrew ('07) stands right where he wants to be, mixing his passion for design with engineering's problem-solving ethos.

As a senior design director at Nike, Andrew helps propel Nike Virtual Studios, home to the company's virtual product platform. The position challenges Andrew intellectually and creatively to stay on the cutting edge of new design tools and technologies to expand and enliven Nike's presence in the ever-expanding virtual product and gaming world.

"It's work that excites me every day," says Andrew, who joined Nike Virtual Studios at its launch in January 2022.

A Washington, D.C.-area native, Andrew was drawn to Northwestern for its rich blend of academic and cultural offerings as well as its proximity to his extended family on Chicago's South Side. He acknowledges that, although he initially felt intimidated by the University's scholarly talent, he gained a much-needed confidence boost from the Minorities in Engineering Opportunity Program (now called the Melville and Jane Hodge EXCEL Scholars Program)—a summer program designed to acclimate incoming engineering students from diverse backgrounds to campus life.

"Forming a network, meeting professors, and learning to navigate campus before the academic year even began gave me a running start," Andrew says. "I saw I could thrive at Northwestern and find happiness here."

He did precisely that.

An electrical engineering and computer science major, Andrew savored learning new concepts and theories. He describes how a business-oriented engineering course taught by Professor William White opened his eyes to the broader applicability of his engineering studies. Through experiences at the University's Ford Motor Company Engineering Design Center and its partnership with design firm IDEO, he embraced the possibilities of blending engineering's problem-solving discipline with emerging design and computer graphics tools.

"I connected with people and ideas well outside my comfort zone, which shaped my career aspirations," he says.

Andrew spent the first dozen years of his professional life in user experience (UX) design. At Acquity Group, he shaped human-computer interaction on projects for Target, OfficeMax, and McDonald's. At VSA Partners, a Chicago-based global creative agency, he helped form IBM Design Studio; at Apple, he advanced interactive retail, blending in-store and digital experiences to increase consumer engagement.

In 2020, he moved beyond UX design when he became head of product design at GOAT Group, an online retail platform for sneakers and apparel. Andrew spearheaded the redesign of the company's website and mobile app, helping to fuel its growth and brand presence over two years.

"I knew how to get unstuck and solve problems, how to work with others, and I had an appetite for learning new things, all skills I developed at Northwestern," Andrew says. "That helped me flourish in my career."

Though Andrew intended to stay at GOAT long term, Nike's enticing call proved too compelling. He jumped onto the Nike Virtual Studios team, immediately coming up with new ways to bring the brand's "amazing heritage of product, innovation, and storytelling to life in interesting ways," particularly for the gaming community.

"It's exciting to see the enthusiasm people have for items they own from Nike's virtual collection," Andrew says. "It pushes me to continue evolving and thinking about what else we can accomplish."

DANIEL P. SMITH

COMBINING BUSINESS SAVVY WITH WHOLE-BRAIN ENGINEERING, **SAMAR SEN** BRIDGES THE GAP BETWEEN TRADITIONAL BANKING AND DIGITAL ASSETS.

Building the Future of Finance

"BORROWING FROM AND COMBINING MULTIPLE DISCIPLINES IS WHAT ENABLES PEOPLE TO INNOVATE. DEEP DOWN, I BELIEVE THAT'S THE FORMULA FOR SUCCESS, AND I WOULDN'T HAVE BEEN ABLE TO DO THAT IN MY CAREER IF IT WASN'T FOR WHAT I LEARNED AT NORTHWESTERN."

SAMAR SEN ('01) has never had so much fun at work.

"I feel the most alive I've ever been in my career," he says. "On Sunday nights, I can't wait for Monday morning. I'm building a team and a product I believe in."

Sen is head of Asia-Pacific at Talos, an institutional digital asset trading platform provider, where he works on advanced technology for trading digital assets and cryptocurrencies. When Sen stepped up to lead the fintech company's business in the Asia-Pacific region in 2021, he was the only employee in the Singapore office. Today, he oversees a team of nearly 20 who serve customers across the region.

He believes Talos is helping build the future of finance by creating a bridge that connects traditional institutions to digital asset markets. "We are the largest provider of this type of technology in the world," he says. "Billions of dollars are traded through our pipes on a weekly basis."

Prior to Talos, Sen held product, strategy, and technology leadership roles at major capital markets firms. He's built a successful career by combining what he learned at Northwestern with creativity and business acumen.

THE WHOLE-BRAIN EXPERIENCE

From a young age, Sen was interested in how technology could transform society. His love of computer science began as a child in Nigeria, where he took coding classes. Over time, he realized that technology complemented his other interests, including art and music.

Originally from India, Sen later moved from Nigeria to England for high school. As he weighed his options on where to pursue his undergraduate studies, he consulted cousins who had studied in the United States. Northwestern soon became the clear frontrunner.

"Northwestern had strong schools outside engineering, which interested me because I was an interdisciplinary guy," he says. "I was good at computers, but I was also a painter and in a rock band. I wanted to go somewhere that let me take classes from different schools."

At the McCormick School of Engineering, Sen enjoyed the flexibility to explore his wide-ranging interests, including art, music, and writing. The school's emphasis on whole-brain engineering is one of the reasons Sen is now active in Northwestern's alumni community in Singapore, where he interviews prospective students. "I'm proud of how Northwestern leans into the idea that computer science isn't just an engineering subject," he says. "It's transforming every field."

Sen credits his intelligent information systems course, taught by Professors Kristian Hammond and Larry Birnbaum, with teaching him design thinking. "The class tested our ability to combine technologies in new ways and envision products that customers really want," he says. "It let me see my strengths as a product builder."

A CAREER OF CREATIVE PIVOTS

Sen had planned to work for a tech company after graduation from Northwestern, but the job offer disappeared when the dot-com bubble burst after 2000. He pivoted to finance and accepted a position at Goldman Sachs, where he applied his technology skills to help develop pioneering trading systems.

Interested in learning more about business operations, Sen earned an MBA from INSEAD and explored its campuses in Paris and Singapore. He chose Singapore as his new base, where he served as vice president at Barclays bank focused on the Asia-Pacific region. Later, he moved to fintech startup TradeHero as global head of business development, strategy, and partnerships. From there, he went on to become a senior digital product manager at bank BNP Paribas.

"I worked in wealth management and corporate banking, and it was an amazing time because Asia went through massive periods of growth and wealth creation," he says. "I became an Asia expert and built up a whole business network across the region."

Sen's shift to digital assets began when he became global head of digital products for securities services at Deutsche Bank, which managed trillions in assets. There he discovered that his true talents lay in fintech.

As he learned more about digital assets and their underlying blockchain technology, Sen was drawn to the idea that companies are building new and better financial plumbing across the globe that allows people to transfer value to each other without fees and access exciting investment products usually reserved for the elite. These new networks are owned by the community rather than a few mega-corporations. Talos is one of the companies building key trading infrastructure for this new world.

Today, he says his role at Talos feels like a culmination of everything he's done so far. "All the unique pivots and skills I picked up along my career helped me reach where I am today," he says. "I'm really proud of being able to marry all my different skills together in this role."

Those skills also include more artistic pursuits. Sen and his wife also run a creative agency that offers design, photography, and film services. Exploring his creativity helps Sen visualize new ways of brand storytelling and advancing product design at Talos.

"Borrowing from and combining multiple disciplines is what enables people to innovate," he says. "Deep down, I believe that's the formula for success, and I wouldn't have been able to do that in my career if it wasn't for what I learned at Northwestern."

SARA LANGEN

IN MEMORIAM

PROFESSOR GOKHAN MEMIK

Gokhan Memik, associate chair and professor of electrical and computer engineering and professor of computer science at Northwestern Engineering, passed away in June. He will be remembered as a pioneering researcher and a dedicated mentor and teacher.

Memik joined the McCormick School of Engineering in 2003. He previously worked as a visiting associate professor of computer engineering at Koç University in Istanbul. Memik investigated research areas at the intersection of computer architecture, computer systems, and manufacturing technologies. His work centered around developing new architectures, modeling and optimizing large-scale systems, and developing techniques that can automatically detect and utilize user needs and requirements to improve the performance of mobile systems and reduce their power consumption.

Memik's recent research interests included studying emerging technologies such as novel nonvolatile memory devices, incorporating holistic effects into the design process, and developing physical-aware architectures.

The author of two book chapters and more than 140 journal and conference publications, Memik and his collaborators secured seven patents. His pioneering research influenced the development of widely used commercial processors. He coauthored NetBench and MineBench, benchmarking suites for networking and data mining applications, respectively. Memik earned a National Science Foundation Faculty Early Career Development Program Award in 2008 and a US Department of Energy Early Career Principal Investigator Award in 2005.

In 2022, Memik received the International Academy of Science and Engineering for Development Distinguished Scientist Award "in recognition of his outstanding scientific contributions to the field of computer architecture."

Between 2005 and 2021, Memik supervised 15 PhD students and seven master's degree students. He earned multiple teaching accolades, including Northwestern's Searle Fellowship for teaching excellence in 2004 and the University of California, Los Angeles's Henry Samueli Excellence in Teaching Award in 2002 and Henry Samueli Fellowship in 2001.

"I will always remember Gokhan as a kind and energetic faculty member who made valuable contributions to our department. He will be sorely missed," says Randall Berry, John A. Dever Chair of Electrical and Computer Engineering.

"This is a profound loss for Northwestern ECE and CS. Gokhan was a mentor to many, and everyone in the department remembers him as kind, thoughtful, and gracious," says Samir Khuller, Peter and Adrienne Barris Chair of Computer Science. "Our thoughts are with his friends and family for their sudden loss."

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Kay Howard Barney '47, '49
Charles A. Fahey '47
Jack R. Houlette '49
Dalbert U. Shefte '49, '52
Glenn S. Shelley '53
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William G. Gensler '54
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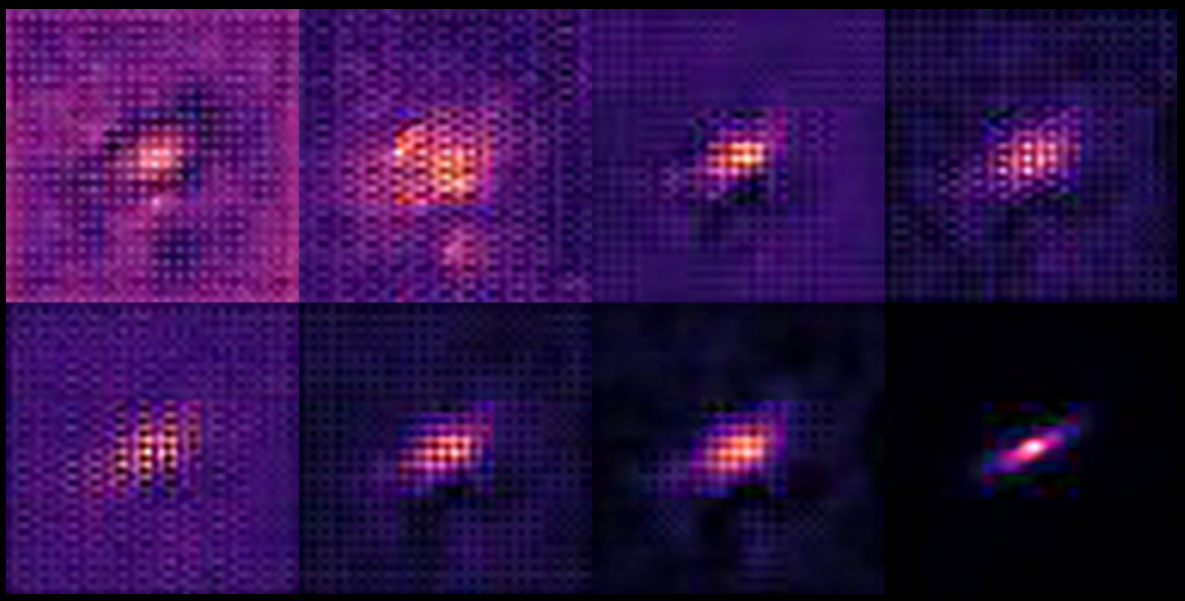
BIG IDEA



AI ALGORITHM UNBLURS THE COSMOS

top image
To remove the atmosphere from an image, the process pushes the starting image through eight layers of network, generating eight intermediate images. Earliest image is top left, and final image is bottom right.

bottom image
Rubin Observatory/ NSF/AURA/B. Quint

When light emanates from distant stars, planets, and galaxies, it travels through Earth's atmosphere before it hits our eyes. Because shifting pockets of air affect the light traveling through the atmosphere, even images obtained by the world's best ground-based telescopes are blurry. This blur obscures the shapes of objects in astronomical images, sometimes leading to error-filled physical measurements that are essential for understanding the nature of the universe.

Emma Alexander, assistant professor of computer science, and a research team from Northwestern and Tsinghua University in Beijing have developed a solution. They've adapted a well-known computer vision algorithm used for sharpening photos and, for the first time, applied it to astronomical images from ground-based telescopes.

The resulting images are blur-free and truer to life. While astrophysicists already use technologies to remove blur, the adapted AI-driven algorithm works faster and produces more realistic images than other technologies in current use. The researchers also trained the algorithm on data simulated to match the Vera C. Rubin Observatory's imaging parameters, so when the observatory opens next year, the tool will be instantly compatible.

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INSTANT EVOLUTION

A team led by Professor Sam Kriegman has developed the first artificial intelligence (AI) to date that can intelligently design robots from scratch. To test the new AI, the researchers gave the system a simple prompt: Design a robot that can walk across a flat surface. While it took nature billions of years to evolve the first walking species, the new algorithm compressed evolution to lightning speed—designing a successfully walking robot in mere seconds.

Photography by Northwestern University

Watch the robots walk.