McCormick School of Engineering and Applied Science

NORTHWESTERN ENGINEERING

SPRING 2024

ACTIVATING AI'S POTENTIAL

EQUIPPING LEADERS TO MEET TOMORROW'S CHALLENGES


N
RESEARCH
White Knight
ENVISION

A LAB WITH A VIEW

Marija Milisavljevic, a PhD student in chemical engineering, conducts protein engineering research inside Northwestern Engineering's new shared synthetic biology laboratory. The lab, located on the fifth floor of Mudd Hall, opened in fall 2023 and features expanded wet lab space supporting the research groups of Professors Neha Kamat, Joshua Leonard, and Keith Tyo.

In addition to its picturesque views of Lake Michigan, the lab also offers office and meeting spaces designed to promote collaboration among researchers in Northwestern's Center for Synthetic Biology, which advances research in engineering biological systems with unique functions that could help address grand challenges in medicine, agriculture, energy, and environmental sustainability.

Photo by Jason Brown

"Throughout my first academic year as dean, I have been delighted to meet so many dedicated faculty, staff, students, and alumni who help to make this school so great. I said at the outset that it was going to be fun, but it has exceeded my loftiest expectations. Our school is prepared for an exciting period of growth and development, and we are grateful to have your support."

GREETINGS FROM NORTHWESTERN ENGINEERING

Artificial intelligence (AI) and data science might be the current buzzwords in technology news, but for those of us in engineering academia, these fields have been at the core of many of our education and research efforts for years.

On the research side, Northwestern Engineering faculty have used these tools to improve next-generation robotics, develop state-of-the-art materials, foster transportation innovation, support urban ecology, and create new diagnostic tests and predictive models for use in medicine. On the education side, our school has developed several master's degree programs to educate future leaders in AI and data science, including a partnership with the Kellogg School of Management to deliver our first blended degree, MBAi. These programs teach students to not only understand the technology, but to also use it to guide new innovations across many disciplines.

Both approaches, which you can read about in this issue, are essential to shaping a future where the power of AI and data science can be harnessed to tackle complex challenges across disciplines.

Also on the research front, last fall Northwestern was awarded $50 million from the US National Science Foundation and the Simons Foundation to establish the National Institute for Theory and Mathematics in Biology. With the University of Chicago, the institute will create a nationwide collaborative research community to uncover the "rules of life" through theories, mathematical models, and computational and statistical tools. These insights could have wide-ranging implications on some of our most pressing problems.

Finally, you can also read how students study these global challenges through our many international experiential learning programs. We encourage our students to step out of their comfort zones to understand the world through a new lens, and many find that these programs teach them more than they could have imagined.

Throughout my first academic year as dean, I have been delighted to meet so many dedicated faculty, staff, students, and alumni who help to make this school so great. I said at the outset that it was going to be fun, but it has exceeded my loftiest expectations. Our school is prepared for an exciting period of growth and development, and we are grateful to have your support.

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

On the Cover
Graduate-level programs in artificial intelligence and data science equip leaders for the new world of AI while researchers push the technology's boundaries across multiple fields. See the story on page 12.

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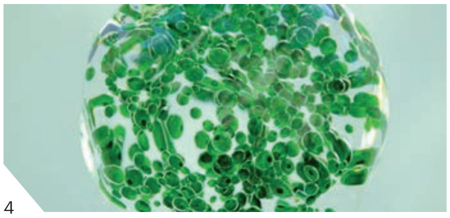
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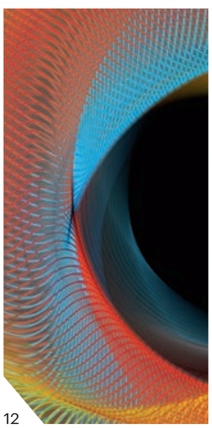
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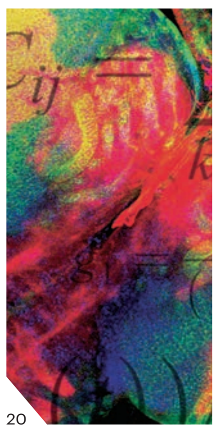
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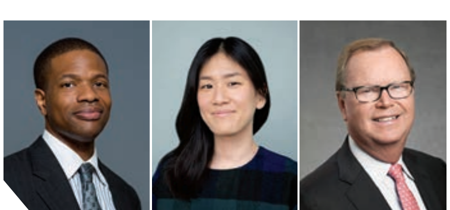
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NEWS

C-THAN Receives up to $8 Million over Five Years

The Center for Innovation in Point-of-Care Technologies for HIV/AIDS and Emerging Infectious Diseases at Northwestern University (C-THAN), housed within Northwestern Engineering's Center for Innovation in Global Health Technologies, received renewal funding of up to $8 million over five years from the National Institutes of Health.

Launched in 2018 with a $7.5 million grant, C-THAN supports collaborations between McCormick School of Engineering researchers and university partners in Africa to foster an ecosystem of point-of-care technology development to better detect and monitor HIV and common fatal comorbidities and complications, including tuberculosis, hepatitis B, hepatitis C, diabetes, heart disease, and certain cancers.

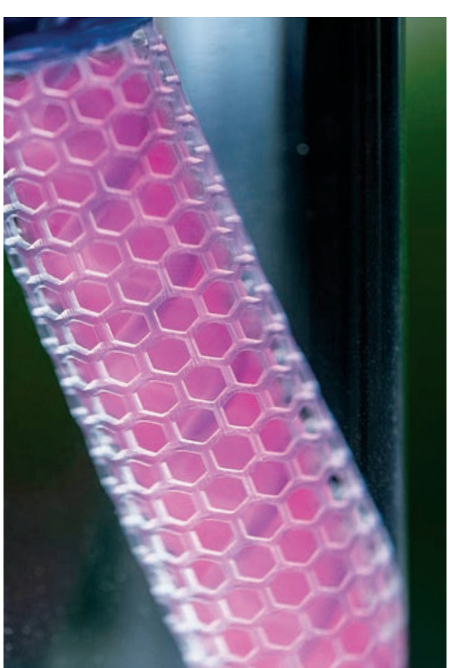
CREATING ALGORITHMS TO BUILD INTERNATIONAL TEAMS

Identifying research partners based in different countries can have immense benefits but can be challenging. Northwestern Engineering's Global Initiatives is working to improve the process. In October 2023, Professor Matthew Grayson hosted the Four Corners Virtual Workshop on Sustainability, bringing together small work groups representing four universities—Northwestern, Tel Aviv University, National Taiwan University, and the University of Hamburg—for research brainstorming sessions. Grayson tested a new algorithm for matchmaking developed by Professor Noshir Contractor. The algorithm created groups of between three and six people, leading to 47 research collaborations on dozens of topics such as food expiration, efficient power generation, and water cleanliness.

"From a clinical perspective, this could be a game-changing approach to cancer therapy. It's personalized, multimodal, and could improve access to care. This concept of a regulated cell-based therapy also is exciting for other areas of medicine, and this project allows us to develop the toolbox of components needed to make it a reality."

JONATHAN RIVNAY Professor of Biomedical Engineering and Materials Science and Engineering

$45 Million Grant to Develop Device to Sense and Treat Cancer



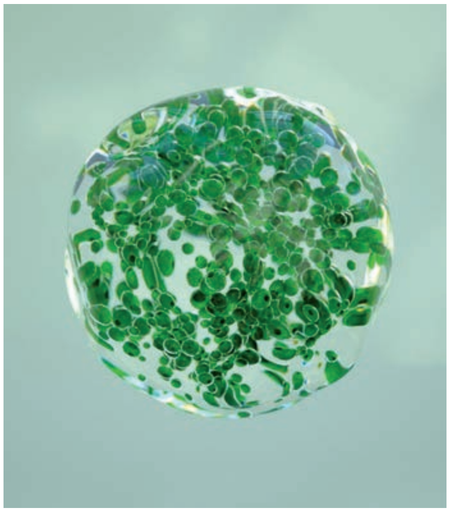
A multi-institutional team of researchers, including Northwestern scientists, received $45 million from the Advanced Research Projects Agency for Health (ARPA-H) to fast-track the development of a first-of-its-kind implant to sense and treat cancer.

ARPA-H is a new federal funding agency that supports research with "the potential to transform entire areas of medicine and health." Northwestern's project is the second program funded under ARPA-H's inaugural Open Broad Agency Announcement solicitation for research proposals.

The funding supports a five-and-a-half-year effort to develop and test a device that can sense inflammatory markers associated with cancer and autonomously deliver immunotherapy. Measuring just one centimeter in diameter, the small implant will house living engineered cells that both synthesize and deliver therapies when needed.

During the first four years, the researchers will develop the technology and test it on small and large animal models. Human clinical trials will begin in year four starting with patients who have recurring ovarian cancer.

The implant could dramatically improve immunotherapy outcomes for patients with ovarian, pancreatic, and other difficult-to-treat cancers—potentially slashing US cancer-related deaths by 50 percent. One of the project's biggest challenges is to overcome the harsh environment inside the human body, which is inhospitable to electronics. The end goal is to develop a device to provide personalized therapy tailored to individual cancer patients.



“Northwestern is part of the team working hard to make this hub a success not only in demonstrating the technology, but also by developing and applying methods to identify how the hub can work towards decreasing greenhouse gas emissions through improving hydrogen production technology, transportation, and storage and applications in multiple end uses.”

JENNIFER DUNN
Professor of Chemical and Biological Engineering

Northwestern Part of National Effort to Develop Hydrogen Fuel Economy

Northwestern University is a key partner in the Midwest Alliance for Clean Hydrogen (MachH2), one of seven new Regional Clean Hydrogen Hubs nationwide with a combined $7 billion in funding to accelerate the domestic market for clean hydrogen.

As the Midwest hydrogen hub, it spans the US industrial and transportation corridor comprising six states, including Illinois.

A coalition of public and private entities, MachH2 represents the various phases of the hydrogen value chain (production, storage and distribution, and consumption and application).

MachH2 plans to produce hydrogen by leveraging diverse and abundant energy sources including renewable energy, natural gas, and low-cost nuclear energy. This hub enables decarbonization through strategic hydrogen uses including steel and glass production, power generation, refining, heavy-duty transportation, and sustainable aviation fuel.

Northwestern Engineering’s Jennifer Dunn, who leads the University’s effort, attended the October 13 ceremony in Philadelphia, where President Joe Biden and Energy Secretary Jennifer Granholm announced the seven hubs. Hydrogen is a valuable energy product that can be produced with zero or near-zero carbon emissions and is crucial to meeting the president’s climate and energy goals.

An expert in the environmental impact of emerging technologies, Dunn and her team of two chemical engineering PhD students will collaborate with the life cycle analysis group at Argonne National Laboratory and researchers at the University of Michigan and Idaho National Laboratory. As chief decarbonization officer for MachH2, Dunn will focus on how expanding the hydrogen economy could help reduce greenhouse gas emissions in the Midwest.

FACULTY NAMED AMONG GLOBAL HIGHLY CITED RESEARCHERS FOR 2023

Sixteen Northwestern Engineering faculty members were named in the Highly Cited Researchers 2023 list by Clarivate. The annual list identifies researchers who demonstrated significant influence in their chosen field or fields through the publication of multiple highly cited papers during the last decade.

Placement on the list is recognized as a significant achievement. Drawn from publications that rank in the top 1 percent by citations for field and publication year in Clarivate’s Web of Science online citation index, those named include:

Vinayak P. Dravid
Omar Farha
Roozbeh Ghaffari
Mark C. Hersam
Yonggang Y. Huang
Joseph Hupp
Mercouri Kanatzidis
Shana Kelley
Tobin J. Marks
Chad A. Mirkin
Jonathan Rivnay
John A. Rogers
Ted Sargent
Randall Q. Snurr
G. Jeffrey Snyder
Chris Wolverton

120%

Amount by which a new fuel cell powered by microbes in dirt and developed by George Wells outlasted similar technologies

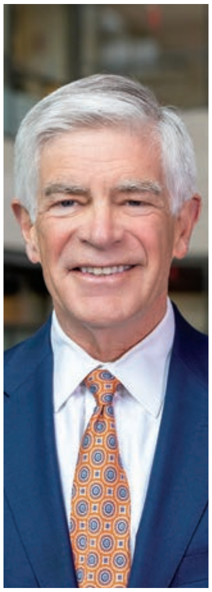
3

Number of weeks earlier than current methods that a new implant developed by John Rogers can detect warning signs of transplanted organ rejection

SHPE RECEIVES GOLD CHAPTER AWARD

Northwestern’s chapter of the Society of Hispanic Professional Engineers received SHPE’s 2023 Gold Chapter Award—the society’s highest honor bestowed upon chapters. Gold Chapter Awards recognize excellence across all four of SHPE’s core values: familia, service, education, and resilience.

Out of more than 300 chapters nationwide, Northwestern SHPE was one of four university undergraduate chapters to receive the award. More than 40 Northwestern members attended the SHPE National Convention in Salt Lake City, Utah, in November to be recognized. “Northwestern SHPE winning the Gold Chapter Award reflects the cumulative efforts and growth of our past and present members in advancing Hispanics and Latines in STEM,” says Steph Maynez, a senior biomedical engineering major and Northwestern SHPE president.



THE BOND BETWEEN ENGINEERING, INFRASTRUCTURE, AND ECONOMICS

As president of the Federal Reserve Bank of Philadelphia, Patrick T. Harker plays a major role in shaping US monetary policies. But Harker began his career as an engineer, and that way of thinking hasn't left his mind.

"As an economist, and especially as president and CEO of the Philadelphia Fed, my goal is to ensure a stable economy that provides opportunities for everyone to grow and succeed," Harker said. "As an engineer, and specifically as a civil engineer, my goal is to ensure a safe, reliable, and stable infrastructure, which provides opportunities for all communities to grow and succeed."

Harker delivered the talk "Fulfilling John Hayford's Legacy: Moving Economics Toward a New Way to Value Infrastructure" at the 2023 Leon N. Moses Distinguished Lecture in Transportation, held November 8 and hosted by the Northwestern University Transportation Center.

MEGAN GREENFIELD URGES GRADUATES TO KEEP GROWING

Megan Greenfield (PhD '09), partner at consulting firm McKinsey & Company, addressed graduates and their families at the 2023 PhD Hooding and Master's Degree Recognition Ceremony held December 9, urging them to embrace a growth mindset. "Even today, my growth mindset is still in full swing," she said. "So, dear graduates, as you embark on your next adventure, pack your growth mindset. Get comfortable being uncomfortable because that's where the magic happens."

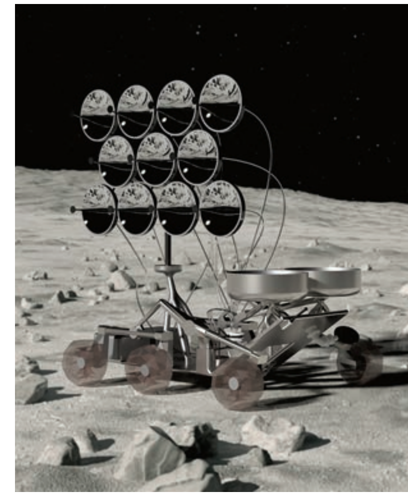
"Your tireless dedication, resilience, and pursuit of excellence have brought you to this pivotal moment. As you take this next step, embrace a growth mindset, find ways to give back, and always set bold aspirations."

MEGAN GREENFIELD Partner, McKinsey & Company

Meet the New Director of Engineering Career Development

Although new to Northwestern Engineering, Erik J. Friedman needed no introduction to the person he replaced. Friedman, who joined the McCormick School of Engineering in September as assistant dean and senior director of the Engineering Career Development office, was hired by Helen Oloroso at Illinois Tech in 1995 and worked for her until 2001. The opportunity to replace his former mentor, who stepped down in 2023, appealed to Friedman, who had spent the previous seven years as associate dean of career development and industry relations at Columbia College Chicago following a 15-year run at DePaul University.

"It's like coming full circle in a way, because when this job came up and I saw the listing I thought 'This is Helen's job,'" Friedman said. "It's a wonderful opportunity for me to see the excellent work that she's done over the years and how I can contribute to take this forward. It's an honor and a privilege."



Student Team Wins NASA Prize

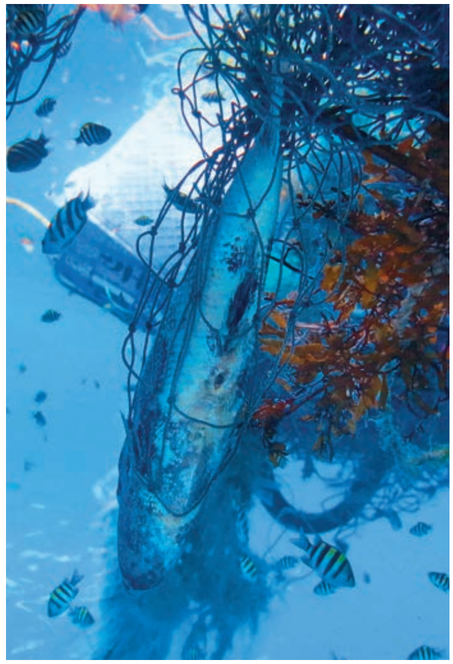
A group of Northwestern Engineering students earned a prize for their effort to help NASA establish a human presence on the Moon. A panel of NASA experts presented the team with the Systems Engineering Award at the 2023 Lunar Forge Challenge held in November at the Glenn Research Center.

The 2023 edition of NASA's annual Breakthrough, Innovative and Game-Changing (BIG) Idea Challenge asked college students to advance a future metal production pipeline on the Moon—from extracting metal from lunar minerals to creating structures and tools. The proposal from the interdisciplinary Northwestern team was one of seven selected for funding earlier in 2023. The team's idea—a method to use concentrated solar energy to cast landing pads and roads into the surface of the Moon—received $167,928.38 in funding.

"I am incredibly proud of the work my team has done, and I can't wait to see the incredible engineering feats they achieve for the 2024 BIG Idea Challenge."

JAIME BERKOVICH
Materials Science and Engineering '23

LAB NOTES



DURABLE PLASTIC POLLUTION EASILY, CLEANLY DEGRADES WITH NEW CATALYST

Many people have seen the haunting images of wildlife tangled in abandoned fishing nets. The most troubling issue with these nets is that the plastic used to construct them, Nylon 6, is too strong and durable to break down on its own. Once in the environment, it lingers for thousands of years.

Northwestern researchers, including Professors Tobin Marks and Linda Broadbelt, developed a new catalyst that quickly, cleanly, and completely breaks down Nylon 6 in a matter of minutes—without generating harmful byproducts. The process does not require toxic solvents, expensive materials, or extreme conditions, making it practical for everyday applications. When the team heated Nylon 6 samples to melting temperatures and applied the catalyst without a solvent, the plastic fell apart—reverting to its original building blocks without leaving byproducts behind. Not only could this catalyst play an important role in environmental remediation, it could also perform the initial step in upcycling Nylon 6 wastes into higher-value products.

"PLASTIC IS A PART OF OUR SOCIETY; WE USE SO MUCH OF IT. BUT THE PROBLEM IS: WHAT DO WE DO WHEN WE'RE FINISHED WITH IT? IDEALLY, WE WOULDN'T BURN IT OR PUT IT INTO LANDFILLS. WE WOULD RECYCLE IT. WE'RE DEVELOPING CATALYSTS THAT DECONSTRUCT THESE POLYMERS, RETURNING THEM TO THEIR ORIGINAL FORM, SO THEY CAN BE REUSED."

TOBIN MARKS Professor of Materials Science and Engineering

Pulling Carbon Dioxide Straight from the Air

Typical carbon capture methods catch CO_2 directly from a carbon-intensive process. Ambient carbon capture, or "direct air capture," on the other hand takes carbon out of typical environmental conditions, making it a weapon in the battle against climate change, particularly as reliance on fossil fuels, and consequently the need for point-of-source carbon capture, decreases.

Professor Vinayak Dravid developed a novel approach to capture carbon from ambient environmental conditions. His innovation considers the relationship between water and carbon dioxide in systems to inform the "moisture-swing" technique, which captures CO_2 at low humidities and releases it at high humidities. The approach incorporates innovative kinetic methodologies and a diversity of ions, enabling carbon removal virtually anywhere.

TRANSLATING HUMAN EXPERIENCES FOR AI TOOLS

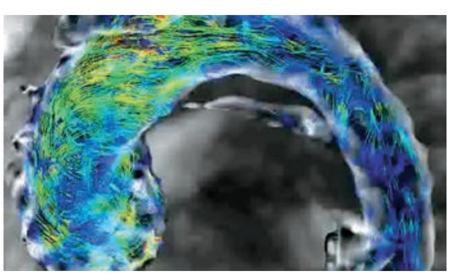
Despite their impressive ability to process an immense amount of data, machines struggle to understand basic human situations. For example, people naturally adapt to changing environments like the weather and can navigate social and cultural differences. Computers often lack this cultural context when making decisions. That could lead to dangerous outcomes in a world that increasingly relies on emerging technologies like artificial intelligence.

Professors Haoqi Zhang and Darren Gergle are helping designers develop rich, accurate descriptions of real-life situations that enable the creation of context-aware computing tools. These include technologies that are responsive to locations, activities, and situations as well as to the meaning that people attribute to what's happening around them. Students in the duo's classes recently have developed ways to translate computer code between context features and high-level human concepts.

Are Consumers Ready for Robots at Their Doorsteps?

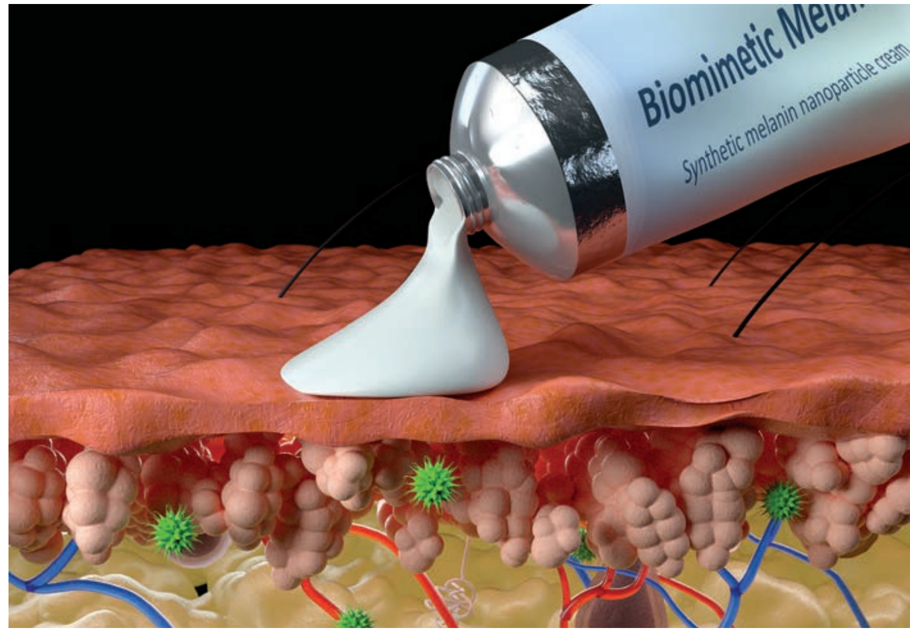
With Amazon making 10,000 drone deliveries in Europe in 2023 and Walmart planning to expand its drone delivery services to an additional 60,000 homes in the United States, companies are investing even more in drone delivery research and development. But are consumers ready to accept this change as the new normal?

Surveying nearly 700 people, Professor Amanda Stathopoulos and her team found a "complex and multifaceted" relationship between behavior and acceptance of near-future technologies for automated parcel delivery. While respondents generally were more willing to accept automated vehicles as substitutes for delivery persons—perhaps because of their familiarity with self-driving cars—they disliked drones and robots as options. However, as delivery speed increased and price decreased, the likelihood to accept the technology increased. Tech-savvy consumers appeared more accepting of the near-future technologies than those less familiar with the technology.



UNSTABLE FLUTTERING PREDICTS AORTIC ANEURYSM

Professor Neelesh Patankar and his team developed the first physics-based metric to predict if a person might suffer an aortic aneurysm, a deadly condition that often exhibits no symptoms before aortic rupture. The researchers forecasted aortic growth by measuring subtle "fluttering" as blood flows through a patient's aorta. While stable flow predicts growth, unstable flutter is predictive of abnormal growth and potential rupture. Called the "flutter instability parameter," the new metric predicted future aneurysm with 98 percent accuracy on average three years after it was first measured.

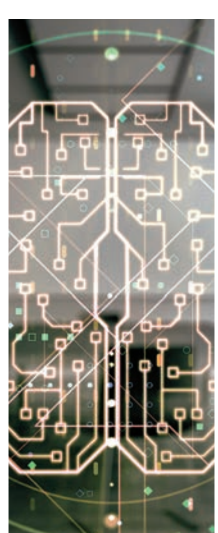


"Super Melanin" Heals Skin Injuries from Sunburn, Chemical Burns

Imagine a skin cream that heals damage to skin exposed to sunlight or environmental toxins throughout the day. That's the potential of a synthetic, biomimetic melanin developed by Professor Nathan Gianneschi and his collaborators.

The researchers showed that their synthetic melanin when applied topically in a cream can protect skin from sun exposure and accelerate healing of skin injured by sun damage or chemical burns. This effect occurs both in the skin itself and systemically in the body. The technology works by scavenging free radicals, which are produced by skin injured, for example, by sunburn. Left unchecked, free radical activity damages cells and may result in skin aging and skin cancer.

The scientists are pursuing clinical translation and trials testing for efficacy of the synthetic melanin cream. In an initial step, the scientists recently completed a trial showing that the synthetic versions of melanin are nonirritating to human skin. The team also surmises that the cream could be an effective treatment for skin burns from radiation exposure.



BRAIN-LIKE TRANSISTOR MIMICS HUMAN INTELLIGENCE

Taking inspiration from the human brain, Professor Mark Hersam and collaborators from Northwestern Engineering, Boston College, and the Massachusetts Institute of Technology developed a synaptic transistor capable of higher-level thinking that, just like the human brain, processes and stores information. In experiments, the researchers demonstrated that the transistor goes beyond simple machine-learning tasks to categorize data and is capable of performing associative learning.

Although previous studies leveraged similar strategies to develop brain-like computing devices, those transistors cannot function outside cryogenic temperatures. The new device is stable at room temperatures. It also operates at fast speeds, consumes little energy, and retains stored information even when power is removed.

RESEARCHERS IDENTIFY BRAIN CENTER RESPONSIBLE FOR RESPONSES TO RAPID TEMPERATURE CHANGE

A team that included Professor William Kath identified a brain pathway in fruit flies responsible for detecting threats rapidly. Using a high-resolution camera, the team observed the flies navigating different temperature environments. When flies encounter a rapid heat front, they always take a U-turn away from it. The lab found flies always responded in cases of rapid temperature change, but not of slow change.

The team identified a circuit in the fly brain that responds only to rapid temperature change (more than 0.2 degrees Celsius per second). These neurons fired at the beginning of rapid heating and then went quiet. Kath's graduate student built a small computer simulation of a vehicle with two antennae and two wheels to demonstrate how adding a neuron that anticipates dangerous heat could improve the flexibility of the vehicle's response.

25%

Efficiency of an inverted perovskite solar cell developed by Ted Sargent, a record for the material

260

Participants in Northwestern's Conference on AI and National Security, which showcased the work of the Northwestern Security and AI Lab

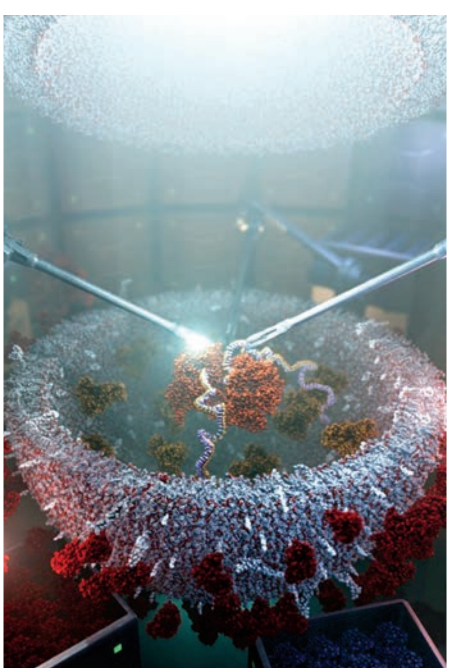
FIRST-OF-A-KIND WEARABLES CAPTURE BODY SOUNDS TO MONITOR HEALTH CONTINUOUSLY

Physicians listen to the sounds of their patients' bodies—air moving in and out of the lungs, heartbeats, and even food progressing through the gastrointestinal tract—to gain valuable information about their health.

Northwestern researchers led by Professor John Rogers introduced new soft, miniaturized wearable devices that go well beyond episodic measurements obtained during occasional doctor exams. Adhered to the skin, the devices continuously track subtle sounds simultaneously and wirelessly at multiple locations across nearly any region of the body.

In pilot studies, researchers tested the devices on 15 prematurely born babies with respiratory and intestinal motility disorders and 55 adults, including 20 with chronic lung diseases. Not only did the devices perform with clinical-grade accuracy, they also introduced new functionalities not previously available in research or clinical care.

New Platform Solves Key Problems in Targeted Drug Delivery



Cell and gene therapies have shown promise for treating cancer, diabetes, heart disease, HIV/AIDS, and other difficult-to-treat diseases. However, the lack of effective ways to deliver biological treatments into the body has posed a major barrier for bringing these therapies to the market.

Northwestern synthetic biologists, including Professors Josh Leonard and Julius Lucks, developed a flexible new platform that solves part of this daunting challenge. Mimicking natural processes used by viruses, the delivery system binds to target cells and effectively transfers drugs inside.

The workhorses behind this new platform are extracellular vesicles (EVs)—tiny, virus-sized nanoparticles that all cells produce naturally. Researchers used the powerful approach of synthetic biology to build DNA "programs" that—when inserted into "producer" cells—direct those cells to self-assemble custom EVs with useful surface features. The programs also direct cells to produce and load the EVs with biological drugs.

In proof-of-concept experiments, the particles successfully delivered biological drugs—in this case, CRISPR gene-editing agents that knocked out a receptor used by HIV—to T cells, which are notoriously difficult to target. It marks the first study to successfully use EVs to deliver cargo into T cells.

Called GEMINI (Genetically Encoded Multifunctional Integrated Nanovesicles), the new platform represents a suite of technologies for genetically engineering cells to produce multifunctional EVs to address diverse patient needs.

"INSTEAD OF DESIGNING A NEW DELIVERY SYSTEM EVERY TIME A COMPANY MAKES A NEW DRUG, WE HOPE THAT THEY CAN INSTEAD USE MODULAR, RECONFIGURABLE PLATFORMS LIKE OURS, THUS ACCELERATING THE RATE AT WHICH GENE AND CELL THERAPIES ARE DEVELOPED AND EVALUATED."

JOSHUA LEONARD Professor of Chemical and Biological Engineering

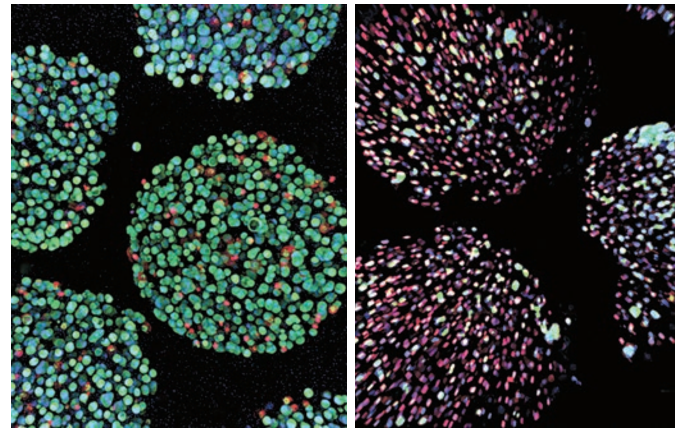
PATIENT-FOCUSED AI SYSTEM SEEKS TO REDUCE STRESS DURING PREGNANCY

Anyone having a baby knows there's a long list of things to avoid during pregnancy, including stress. Professors Maia Jacobs and Nabil Alshurafa are studying expectant mothers' stress levels to combat stress in real time and even prevent it.

They and their teams created a machine-learning system that uses sensors on the body and participant responses to smartphone-based questions to predict whether tomorrow is going to be a stressful day. When high stress levels are detected, the system sends the user text messages or links to videos that have been proven to reduce stress. The team worked with 20 pregnant people to get their feedback on the next-day stress prediction tool and are now analyzing the data before redesigning the tool's user interface.

"THE GOALS ARE TO PREEMPT STRESS, REDUCE YOUR CHANCES OF HAVING STRESSFUL DAYS, AND GIVE YOU THE RIGHT TOOLS AT THE RIGHT TIME TO HELP YOU NAVIGATE A STRESSFUL SITUATION."

NABIL ALSHURAFA Associate Professor of Preventive Medicine and Computer Science and Electrical and Computer Engineering



A Breath of Fresh Air Keeps Drug-Producing Cells Alive Longer

Researchers co-led by Professor Jonathan Rivnay developed a new device that produces oxygen at the site to keep cells alive inside the self-contained implant. Oxygen is a major ingredient for keeping cells alive for longer periods of time inside of an implantable "living pharmacy," which engineers cells to produce the same peptides the body makes to regulate sleep cycles. The longer that cells can stay alive and healthy, the longer they can autonomously produce therapeutics for the body. By using electricity to split water the cells are already bathed in, the researchers produced oxygen while avoiding the production of harmful byproducts.

"It's estimated that synthetic nitrogen fertilizer supports half of the global population. A chief priority of decarbonization efforts is to increase quality of life on Earth, while simultaneously decreasing society's net CO_2 intensity. Figuring out how to use renewable electricity to power chemical processes is a big opportunity on this score."

TED SARGENT Professor of Electrical and Computer Engineering

Hybrid Catalyst Produces Critical Fertilizer and Cleans Wastewater

Modern agriculture relies on synthetic nitrogen fertilizer, which is made using energy- and carbon-intensive processes and creates nitrate-containing runoff.

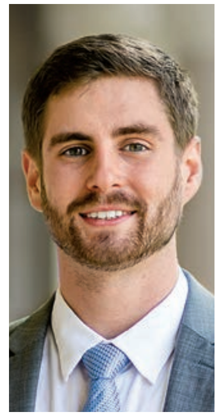
A collaboration between Professors Ted Sargent and Jennifer Dunn, partnering with the University of Toronto, asked the question, "Can we use waste nitrogen sources, captured CO_2, and electricity to create urea?" They found that producing the fertilizer urea using electrified synthesis could both denitrify wastewater and enable low-carbon-intensity urea production.

The process, which includes converting carbon dioxide and waste nitrogen by using a hybrid catalyst made of zinc and copper, could benefit water treatment facilities by reducing their carbon footprint and supplying a potential revenue stream.

Many researchers have developed alternate routes to make ammonia, a precursor to many fertilizers, but few have looked at urea, which is a shippable, ready-to-use fertilizer with a global market of more than $100 billion.

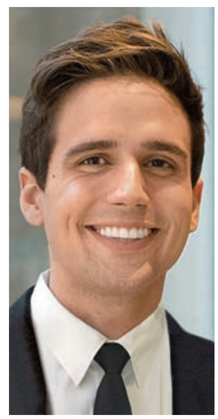

Mark Hersam


Hooman Mohseni


Dayne Swearer


Yonggang Huang


Simge Küçükyavuz


Ian McCue

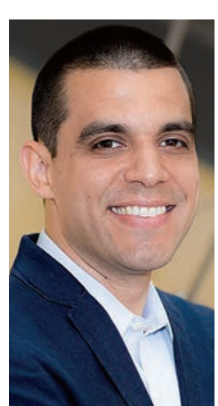

Zdeněk P. Bažant


Richard Lueptow


Ryan Truby


Shana Kelley


James Rondinelli


Jeffrey Lopez

Faculty Awards

Mark Hersam Elected to National Academy of Engineering

Hersam, a leader in nanomaterials, was cited for his work in the synthesis, purification, functionalization, and application of low-dimensional nanoelectronic materials.

SES Renames Engineering Science Medal in Honor of Yonggang Huang

The Yonggang Huang Engineering Science Medal from the Society of Engineering Science will recognize a singularly important contribution to engineering science.

ASME Establishes Zdeněk P. Bažant Medal

The honor from the American Society of Mechanical Engineers recognizes an individual who has made significant contributions to the field of mechanics through research, practice, teaching, or outstanding leadership.

Shana Kelley, Hooman Mohseni Named to National Academy of Inventors

The NAI Fellows Program recognizes academic inventors who have demonstrated a "spirit of innovation" by creating or facilitating inventions that have made a tangible impact on quality of life, economic development, and social welfare.

Simge Küçükyavuz Named 2023 INFORMS Fellow

In receiving one of the operations research profession's highest honors, Küçükyavuz was recognized for outstanding research in mixed-integer optimization and stochastic optimization and service to the profession.

Richard Lueptow Elected Fellow of the American Institute of Chemical Engineers

The honor is the highest grade of AIChE membership and recognizes Lueptow's distinctive professional achievements and accomplishments.

James Rondinelli Elected a 2023 American Physical Society Fellow

Rondinelli was cited for his innovative contributions in the theoretical understanding of structure-property relationships in novel materials and for his leadership in the materials physics community.

Dayne Swearer Awarded 2023 Packard Fellowship

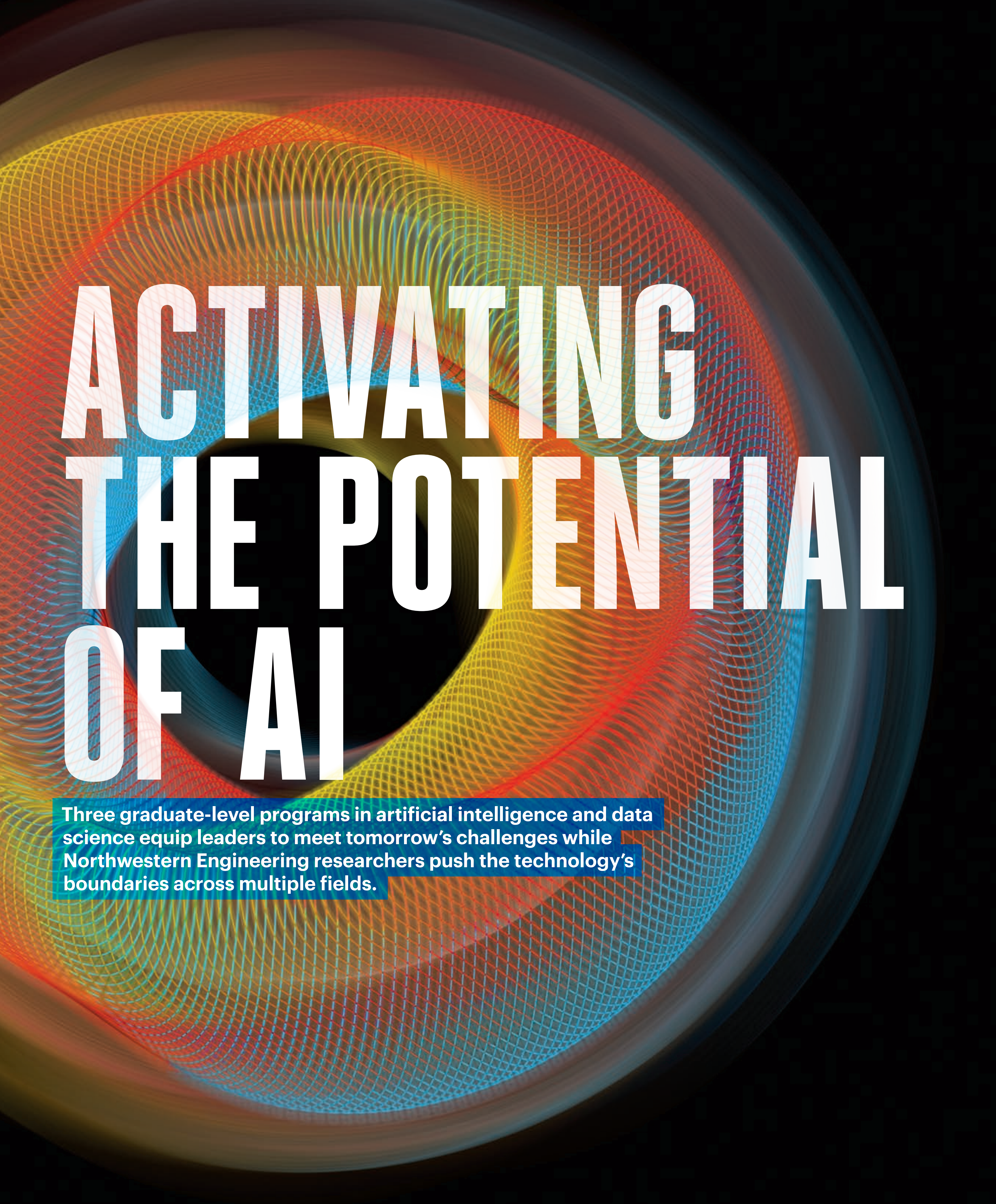
The program honors the nation's most promising early-career scientists and includes an unrestricted grant of $875,000 over five years to pursue innovative and experimental research.

Ian McCue, Ryan Truby Earn DARPA Young Faculty Awards

McCue and Truby will each receive a two-year award of $500,000 as part of the program, which aims to identify and engage standout researchers in junior faculty positions.

Jeffrey Lopez Receives Prestigious NSF CAREER Award

The award, worth $623,708 over five years, will back Lopez's work to design and evaluate new fluorine-free electrolytes.



ACTIVATING THE POTENTIAL OF AI

Three graduate-level programs in artificial intelligence and data science equip leaders to meet tomorrow's challenges while Northwestern Engineering researchers push the technology's boundaries across multiple fields.

PREPARING LEADERS FOR THE NEW WORLD OF ARTIFICIAL INTELLIGENCE

AI is poised to impact nearly every domain, including research, business, media, the arts, and even governments. It's already being used to open up new avenues of discovery, develop novel methods of market analysis, and create innovative products, music, books, images, and more. In 2023, McKinsey & Company estimated the economic potential of generative AI alone could be as much as $4.4 trillion annually.

Yet technology alone will not realize this enormous potential. Businesses need to invest in talent capable of developing, applying, and managing these technologies and the products and services that use them.

To equip students to navigate and meet the challenges of this new frontier with confidence, Northwestern Engineering offers a trio of master's degree programs. Each aims to ground tomorrow's leaders in the technology from three unique perspectives—data scientists/machine-learning engineers, AI application developers, and AI executive leadership—as well as prepare them to use it wisely as they assume positions of influence and power in the world.

MS IN MACHINE LEARNING AND DATA SCIENCE

LEVERAGING THE FULL VALUE OF DATA

Enterprise AI applications that use complex data to drive mission-critical business processes rely on the development of rigorous models. The engineers who build these models must have the technical depth, skill, and experience to ensure their accuracy and relevance.

Launched in 2011, the Master of Science in Machine Learning and Data Science (MLDS)—formerly Master of Science in Analytics—teaches students how to use complex data, maximize its value, and develop and deploy enterprise machine learning and AI applications to advance goals and meet the needs of the technology's users. Students also learn how to design creative solutions, communicate effectively with a variety of audiences, and lead teams and projects successfully.

"We hear from our industry advisory board, from project partners, and from internship sponsors about the various ways the program addresses technological changes coming down the pike before they happen," says Diego Klabjan, professor of industrial engineering and management sciences and MLDS director. "What MLDS does very well is prepare students for such changes so they can enter an internship or the job market able to take on the challenges that happen in real time."

MLDS is housed within the Department of Industrial Engineering and Management Sciences. The program's students, who come from a variety of backgrounds, learn how to apply data from practitioners in multiple industries including healthcare, sports, retail, and entertainment. With only 55 or so students admitted into each cohort, MLDS creates strong bonds among participants as they progress through the program together and graduate into positions as software engineers, data scientists, and analysts.

"Students who make the most of their time here are going to investigate industries they didn't think they were personally interested in," Klabjan says. "It helps them take that broad view that generalists have and then go out into the world able to speak to any number of industries using the content they've acquired while in the program."

"STUDENTS WHO MAKE THE MOST OF THEIR TIME HERE ARE GOING TO INVESTIGATE INDUSTRIES THEY DIDN'T THINK THEY WERE PERSONALLY INTERESTED IN."

Diego Klabjan
Professor of Industrial Engineering and Management Sciences, MLDS Director

Prior to entering the MLDS program, Jason Summer (MLDS '22) worked in data science and advanced analytics. Fueled by an internship with Nike where he developed a learning model to predict customer purchases, Summer landed a full-time position as a solution innovation architect at Snowflake, a cloud computing and AI company.

"A couple classes did a wonderful job portraying how data science can be operationalized appropriately and effectively at organizations," Summer says. "These classes helped me better grasp how to engineer AI/ML solutions at scale while successfully communicating and advocating for their success."

While MLDS focuses on technical skills, the program also works to hone the soft skills like communication and translation that graduates will need in the business world.

"We're not training students to work in individual silos. That's not how they're going to function when they graduate. They're going to graduate into team-based roles, so coursework and projects really simulate that environment," says MLDS associate director

Stephen Dowling. “The ability not only to function collegially on a team, but also to lead a team and understand the nontechnical aspects of data science that can often make or break a team is something we focus on.”

Summer and students like him put their lessons into practice not only in class or internships, but also in their capstone projects. Such an opportunity proved valuable for Summer, providing him firsthand experience in places he had none before.

“MLDS allowed me to assist a biomedical startup in its game-changing research to identify maternal and fetal risk during pregnancies,” Summer says. “It also provided an opportunity to collaboratively develop ML with classmates in a fast-paced environment with multiple interdependent pieces.”

Sharika Mahadevan (MLDS ’23), now an analytics engineer at Netflix, was impacted in similar ways.

“The program helped me build a strong foundation of skills and knowledge needed to start a career in the data science field,” she says. “What’s really important to improve yourself is the opportunity to apply this knowledge. I feel that I had that through the practicum and capstone projects. The program also kept up with the latest trends in the industry. This is very important in a field such as data science that is constantly evolving.”

MS IN ARTIFICIAL INTELLIGENCE

LEADING AI DEVELOPMENT THROUGH TECH, BUSINESS, AND HUMAN PERSPECTIVES

AI provides new ways of engaging systems using language and reasoning but can be imprecise and risky. Employing these capabilities requires an understanding of how these technologies work and an ability to reap the potential benefits while avoiding myriad potential risks and pitfalls.

Launched in 2018, the Master of Science in Artificial Intelligence (MSAI) program was created to meet the demand from industry for individuals who understand AI systems and the problems they can solve. The program equips students with the skills to create powerful AI systems that integrate with workflows, business applications, and human interactions.

“AI has been involved in transforming a lot of fields,” says Kristian Hammond, Bill and Cathy Osborn Professor of Computer Science and MSAI director. “It is incumbent upon us to make sure that our students can lead as opposed to going into organizations and just following along.”

For students interested in defining how AI can be used in businesses across domains, MSAI offers a unique educational path. All core courses are AI-focused, starting with classes that establish a baseline of understanding before moving onto advanced topics such as knowledge representation and commonsense reasoning. The program’s final three quarters prepare students to work in industry through experiential activities, including a practicum where they work on projects proposed by researchers in other Northwestern

Kristian Hammond

Priyanka Aryal works with classmates during the MSAI Hackathon in 2023. Photo by Joel Wintermantle

schools, and a capstone comprising a collaboration with students from the MBAi program to engage in a project posed by a leading company partner.

“The electives also played a significant role in enhancing our knowledge base,” Simon Zouki (MSAI ’23) says. “This flexibility allowed us to tailor our education by selecting courses aligned with our career goals and aspirations, which was crucial to understanding the concepts thoroughly.”

Priyanka Aryal (MSAI ’23), now a full-time research assistant at Northwestern’s Center for Advancing Safety of Machine Intelligence (CASMI), partnered with EY for her capstone project to develop a tool designed to streamline portfolio analysis and determine the need for divestiture, employing various prompt engineering techniques and closely integrated large language models (LLMs) and generative AI into the project.

“Collaborating with EY alongside students from Kellogg provided a unique experience that could be possible only through this program,” Aryal says. “Exploring emerging technologies and witnessing how companies adapt and evolve with the implementation of new generative AI technologies were fascinating aspects of the project.”

Students also learn from Department of Computer Science faculty members, many of whom have extensive industry experience developing enterprise-grade solutions.

“Before enrolling, I didn’t have a comprehensive grasp of AI concepts, algorithms, and techniques,” Aryal says. “But through the coursework, I developed proficiency in areas like machine learning, deep learning, natural language processing, and computer vision. The emphasis on practical application was invaluable. Collaborating with industry partners on capstone and practicum projects allowed me to implement my knowledge in real-world scenarios.”

Today, one of the most pressing needs in industry is solutions that can navigate and harness the power of LLMs, such as ChatGPT. That’s an area where MSAI is ahead of the game.

“It’s not just language. It’s not just a picture. It’s several modalities of AI, including audio and video, and they need to be integrated to make impactful and safe systems,” says Mohammed Alam, the program’s deputy director. “Putting things together is a special skill; you have to know how to do it. That’s what we’re pushing our students to learn, how to use LLMs and other modalities of AI efficiently, safely, and ethically.”

THE MBAi PROGRAM

DEVELOPING TECHNOLOGY-LITERATE LEADERS FOR THE AI AGE

Founded in 2021, this AI-focused MBA program offered jointly with the Kellogg School of Management responds to the growing global need for technically deep executive leaders. The intent of the MBAi program is to develop technical product managers and technology strategists who are as effective engaging a team of data scientists as they are the C-suite—a group that can often be misinformed about the precise capabilities of AI.

Even in the relatively short span of its existence, the program has adapted to the changing AI landscape.

"I reminded our most recent graduating class that at the time they enrolled in the program, ChatGPT hadn't come out yet," says Andrew Fano, clinical professor of computer science and director of the MBAi program. "It was also over the time they were here that LLMs gained real popularity. The proliferation of LLMs has changed everything, including more emphasis in the coursework and the capstone. That reflects the interest shown by companies."

While technology captures the public's interest, MBAi's cohort of 40 to 50 students develops skills in business and technology. MBAi students take the same core MBA courses as Kellogg's standard two-year program, with some courses tailored to emphasize AI and technical topics. Students also take technical courses from the McCormick School of Engineering that accelerate their fluency in analytics and complex technologies. This includes programming in Python, understanding data structures, and techniques for business problem translation, management, applications, and scale. As a result, there is a greater applied focus, with attention paid to the organizational and business implications of technical choices.

"THE PROLIFERATION OF LLMs HAS CHANGED EVERYTHING, INCLUDING MORE EMPHASIS IN THE COURSEWORK AND THE CAPSTONE. THAT REFLECTS THE INTEREST SHOWN BY COMPANIES."

Andrew Fano
Clinical Professor of Computer Science,
MBAi Director

"The program broadened my knowledge of organizational and industry dynamics. It also deepened my knowledge of how data and AI can be leveraged to solve complex problems," says Nolan Hartwick (MBAi '22), now a digital aircraft strategy manager for United Airlines. "Broadening and deepening my knowledge base has allowed me to be more creative and effective in problem-solving."

Students present their capstone projects during the MBAi + MSAI Capstone Showcase in December 2023.
Photo by Carlos Javier Ortiz

While the MBAi curriculum can open career paths for graduates in industries such as financial services or consulting, it also makes them attractive to a wider range of employers. This is accomplished, in part, through MBAi's joint capstone with the MSAI program. In 2023, 17 teams of MBAi and MSAI students worked on projects posed by 15 businesses ranging from Fortune 100 companies to startups. Topics included brand-aligned generative AI content and driving sales effectiveness with AI. The experience culminated in the MBAi + MSAI Capstone Showcase held in December.

"We bring in strengths from the business school, and we understand how to manage teams and how to build a business case, and the other teammates from MSAI, those guys bring in all the technical expertise," says Ameen Shaik (MBAi '23). "Those guys are the brains behind what we built."

Two years ago, one of the program's top capstone projects was for farming-giant John Deere. Several program alumni now work for the company.

"Before coming here, most of our students probably never had a chance to think about problems in agriculture," Fano says. "There are a lot of companies like John Deere that are doing very interesting work not readily visible to students because it's not a business-to-consumer segment."

Hartwick saw that too. His capstone project helped a large business-to-business technology retailer increase its search-to-cart rates by using language models to better categorize and understand the intent of user searches.

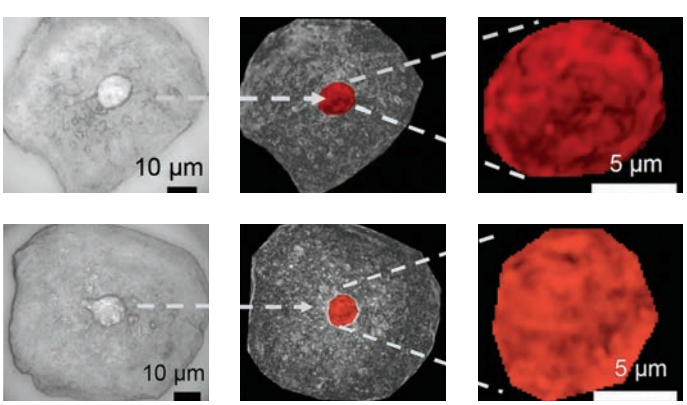
"It was a busy 10 weeks, but our team was able to scope the problem, build a solution, quantify the impact, and recommend next steps," Hartwick says. "Our corporate sponsors were highly engaged with us throughout the whole project, and we were even able to make on-site presentations to a number of executives, including the chief technical officer."

"Each of these three programs prepares students for distinct but related career paths," Fano says. "The collaboration across programs, and between Northwestern Engineering and Kellogg, is a testament to Northwestern's spirit of breaking boundaries and focusing on students and their opportunities."

THE FAR-REACHING IMPACTS OF AI

Northwestern Engineering faculty harness the emerging technologies of AI and data science in fields ranging from materials discovery to robotics to make a positive impact on humanity.

Robotics Project DRIVE aims to bring to market the first active driving assistance system for power wheelchairs, increasing access to safe, independent wheelchair operation. Photo by Shane Collins



Medicine An image of buccal mucosa cells—located in the cheeks and lungs—in a control patient (top) and patient with lung cancer (bottom). The chromatin packing in the cell's nucleus is highlighted in red.

ROBOTICS

MACHINE INTELLIGENCE ACCELERATES POWER WHEELCHAIR ACCESSIBILITY, SAFETY

Autonomous robotics could prove life-changing for millions of people with severe motor impairments who find existing models of power wheelchairs overly burdensome.

Project DRIVE—a multidisciplinary partnership spearheaded by Northwestern Engineering's Brenna Argall and collaborators from academia, industry, and nonprofits—aims to bring to market the first active driving assistance system for power wheelchairs.

To create the wheelchair, the team is making radical changes in how control inputs are interpreted from movements of the human body and communicated to the wheelchair control system. The team is using AI and machine-learning systems to help facilitate wheelchair operation and ensure safety.

"We're aiming to address barriers to independent wheelchair mobility," says Argall, associate professor of computer science and of mechanical engineering at the McCormick School of Engineering and associate professor of physical medicine and rehabilitation at Northwestern University's Feinberg School of Medicine.

"SEEING TECHNOLOGY FROM MY LAB ROLL OUT INTO A COMMERCIAL PRODUCT IS SUPER EXCITING. WE'RE DOING THIS WORK BECAUSE WE WANT TO SEE IT MAKE AN IMPACT IN THE WORLD."

Brenna Argall
Associate Professor of Computer Science and Mechanical Engineering

The wheelchair intelligence thrust will integrate two active driver assistance paradigms built by Argall's team into a commercial assistance system for power wheelchairs. The system's REACT active corrective assistance system adjusts the user's command to avoid collisions and drop-offs, while Project DRIVE's ROUTE assistance system autonomously drives the wheelchair to a target destination within a known environment mapped by recorded data from sensors.

Project DRIVE, supported by a $5 million grant from the US National Science Foundation, aims to roll out the active assistance add-on to beta testers by the end of 2024 and to all users of this type of wheelchair as an opt-in feature by the end of 2025.

"Seeing technology from my lab roll out into a commercial product is super exciting," Argall says. "We're doing this work because we want to see it make an impact in the world."

MEDICINE

HOW AI AND A CHEEK SWAB COULD HELP FIGHT CANCER

The five-year survival rate for lung cancer—the leading cause of cancer deaths in the United States—is 56 percent for cases when the disease is still localized, according to the American Lung Association. Unfortunately, only 16 percent of cases are diagnosed at that stage. When the disease has spread to other organs, the survival rate plummets to 5 percent.

A novel diagnostic test from Northwestern Engineering's Vadim Backman and the Center for Physical Genomics and Engineering (CPGE) could help doctors make that crucial discovery earlier and save more lives.

"SUCH A SIMPLE, EASY-TO-ADMINISTER, AND ACCURATE TEST COULD INCREASE PATIENT UPTAKE, IMPROVE EARLY DETECTION, AND REDUCE MORTALITY AS WELL AS REDUCE FALSE POSITIVES AND UNNECESSARY PROCEDURES."

Vadim Backman
Sachs Family Professor of Biomedical Engineering and Medicine, CPGE Director

Based on a new paradigm for cancer detection and designed for use at home or in a primary care office, the test uses artificial intelligence-enhanced optical nanosensing of alterations in the chromatin (genome) structure of cells—changes that are associated with the earliest stages of carcinogenesis and cancer progression.

The test uses a concept called field carcinogenesis as the source of this new biomarker. Chromatin alterations associated with early lung cancer are detectable not just in a lesion or tumor, but in the nucleus of cells throughout the organ "field"—in this case, from the lungs to the cheeks. That means chromatin alterations could be discovered using a simple, noninvasive method, like a swab of cheek cells, at a stage when lung cancer is more curable.

"Such a simple, easy-to-administer, and accurate test could increase patient uptake, improve early detection, and reduce mortality as well as reduce false positives and unnecessary procedures," says Backman, Sachs Family Professor of Biomedical Engineering and Medicine at Northwestern Engineering and director of the CPGE.

For this work, Backman collaborated with Ankit Bharat, Harold L. and Margaret N. Method Professor of Surgery and chief of thoracic surgery in the department of surgery at the Northwestern University Feinberg School of Medicine.

Sanjay Mehrotra has devoted the last half of his research career to improving healthcare decision-making through data science and predictive modeling. Photo by Jason Brown

DATA SCIENCE IMPROVES KIDNEY ALLOCATION

Some 7,000 potential donor kidneys are discarded each year in the United States because of mishandling. To optimize kidney allocation, Northwestern Engineering's Sanjay Mehrotra turned to machine learning.

Mehrotra's work focuses on overcoming "cold time"—the period during which the kidney is out of the donor's body—to improve the discard rate and better serve the 90,000 Americans awaiting a new kidney. A successful transplant often needs to occur within 24 hours. Presently, because of outdated and inefficient systems, there is a 30-minute time lapse in transplant program decision-making that increases the cold time.

"In such a tight timeframe that needs to account for logistics like air and ambulance travel, every 30 minutes matter," says Mehrotra, professor of industrial engineering and management sciences and director of the Northwestern-based Center for Engineering Health.

"IN SUCH A TIGHT TIMEFRAME THAT NEEDS TO ACCOUNT FOR LOGISTICS LIKE AIR AND AMBULANCE TRAVEL, EVERY 30 MINUTES MATTER."

Sanjay Mehrotra
Professor of Industrial Engineering and Management Sciences, Center for Engineering Health Director

To expedite this logistical process, Mehrotra is leveraging his expertise in data science and predictive modeling. He started with baseline kidney characteristics before forecasting the likelihood of kidneys being transplanted based on a diverse mix of data and variables, such as the donor's health history and cause of death. His work demonstrates that kidneys at risk of discard could be more accurately identified using machine-learning techniques.

"If you know that a kidney is going to be rejected in the current allocation system, then you can say, 'Look, this is a kidney I need to pay attention to very early on and send it down a more expedited pathway where it doesn't accumulate that much cold time and can still get transplanted,'" Mehrotra says.

MATERIALS

SCALING MATERIALS DISCOVERY WITH AI

Lattice thermal conductivity, a fundamental property of materials, plays a vital role in many technological applications, including thermal energy conversion and management.

Understanding its lower limit—known as its minimum thermal conductivity—is crucial. Such knowledge helps scientists understand a material's capabilities but is challenging to attain. Professor Chris Wolverton and his teammates built a machine-learning 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.

The model allows researchers to calculate the minimum thermal conductivity for upwards of 2,000 compounds. Using the model, Wolverton and his colleagues predicted the minimum thermal conductivity of materials and compared them to experimentally measured values. In some cases, they found similar totals.

"IF YOU COULD SOMEHOW CONVERT A FRACTION OF THAT WASTED HEAT INTO USEFUL ELECTRICAL WORK, IT WOULD BE A GAME-CHANGER."

Chris Wolverton
Professor of Materials Science and Engineering

The system 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. This use of artificial intelligence moves researchers closer to harnessing its capabilities to predict which materials have the best thermal conductivity.

"If you could somehow convert a fraction of that wasted heat into useful electrical work, it would be a game-changer," says Wolverton, professor of materials science and engineering.

"If you give a computer many thousands of example pairings of a chemical formula and its thermal conductivity, the question is, can it learn the relationship between those two? It's a very, very complicated relationship, but if you give it many examples, can it learn that? If it can, then it can predict the relationship for new compositions where you don't already know the thermal conductivity."

DESIGNING NEXT-GEN "SMART" MATERIALS

Northwestern Engineering's Wei Chen is using advanced AI technology to discover new ways to create next-generation "smart" materials with embodied intelligence.

In late 2022, Chen received a BRITE Fellow grant from the National Science Foundation to create a data-driven design framework enabled by AI for the real-time digital design and fabrication of programmable material systems (PMS).

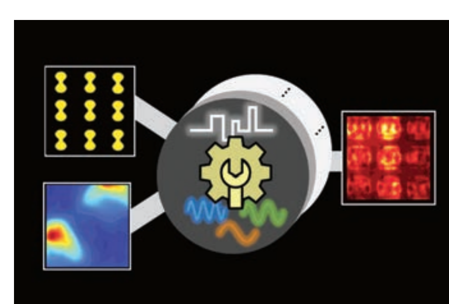
PMS are emerging architectural structures made of smart materials that are responsive to external stimuli and can be programmed to transform between multiple functional states. Impactful applications of PMS are far reaching, including examples such as surgical robots, (bio)sensors, deployable satellites, mechanical computing, and water and energy harvesting.

To address the complex underlying physics and high dimensionality associated with the design of spatially varying materials, architectures, and stimuli, Chen, Wilson-Cook Professor in Engineering Design and chair of the Department of Mechanical Engineering, is working to integrate disruptive technologies across the multidisciplinary domains of design, mechanics, manufacturing, materials, and data science to create a new AI-enabled PMS digital design platform.

Chen is working on a approach named ALGO, which stands for Acquire-Learn-Generate-Optimize. The method employs machine learning and optimization techniques to combine "building blocks" of architectural structures to design the final complex materials and structures. This process aims to increase the speed and efficiency of the design process, leading to better performance and customizable, patient-specific solutions in real-world applications.

"Long-term, our hope is that this research will transform techniques limited to the design of single-material periodic structures into scalable data-driven design of programmable multimaterial systems with heterogenous materials and topological architectures that benefit many physics-driven science and engineering domains," Chen says.

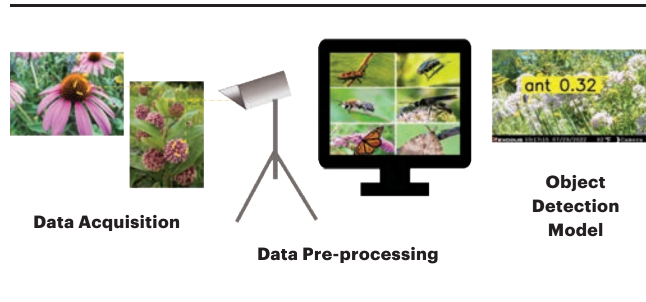
Wei Chen



Wei Chen's interlocking neural operator and concurrent machine learning and optimization techniques boost the optimal design of heterogeneous material systems, enabling dynamic energy hotspot creation on optical metasurface "chessboards."

Amanda Stathopoulos

Kimberly Gray



After collecting field data—such as water storage and pollinator activity—from nearby rain gardens and prairie environments, Kimberly Gray and her team pre-processed the data and then applied machine-learning techniques, which revealed the rain gardens that function most like a natural system and why.

TRANSPORTATION

HOW AI HELPS TEACH US ABOUT HUMAN MOBILITY PATTERNS

Professor Amanda Stathopoulos uses AI and machine learning to understand how humans move through the world.

Stathopoulos, William Patterson Junior Professor and associate professor of civil and environmental engineering, investigates transportation systems to understand how people make transportation decisions. She's also interested in how innovation in transportation impacts society, including its effect on quality of life, prosperity, and equity.

Large-scale geolocated databases are increasingly used by researchers to expand our understanding of mobility patterns. But this type of trace data poses nontrivial analytical challenges in processing and interpretation.

"Researchers often observe only anonymized traces of human activity, but policy makers need to understand how policies affect people and localities," says Stathopoulos, a Northwestern Engineering faculty member since 2014. She and her team have developed analytical methods that consolidate a range of public data sources to understand better the economic and spatial contexts of these big datasets, which, in turn, enables them to understand the impacts of policies without violating privacy regulations.

For example, Stathopoulos investigated the relationship between socioeconomic disadvantages and the availability of on-demand ride-sharing services. Leveraging millions of records from ride-sharing operators coupled with demographics and transit access datasets, Stathopoulos found the highest level of demand for ride-sharing existed in areas that already had other established transportation options.

"In my lab's research on mapping adoption of different ride-hailing options, we relied on knowledge of Chicago-area land use, socio-demographic factors, and coverage of transit to understand the variation in adoption across the city," says Stathopoulos, a member of the Northwestern University Transportation Center. "Our machine-learning techniques illustrated how new mobility options ultimately provided mobility benefits for privileged populations."

Blending math and psychological realism to understand behavior, Stathopoulos uses quantitative and qualitative data streams to generate a holistic understanding of transportation-related behaviors. "My hope is that the behavioral models we put forward have a positive impact on society and address what residents really need from transportation systems," Stathopoulos says.

URBAN ECOLOGY

USING MACHINE LEARNING TO OPTIMIZE GREEN INFRASTRUCTURE

Stormwater that runs off buildings and paved streets frequently carries high levels of pollutants into rivers and lakes, some of which serve as sources of drinking water. Rain gardens, green infrastructure initiatives designed to mimic natural systems such as native prairies, help keep urban runoff out of sewers and sur-face waters, suppressing stormwater's negative effects.

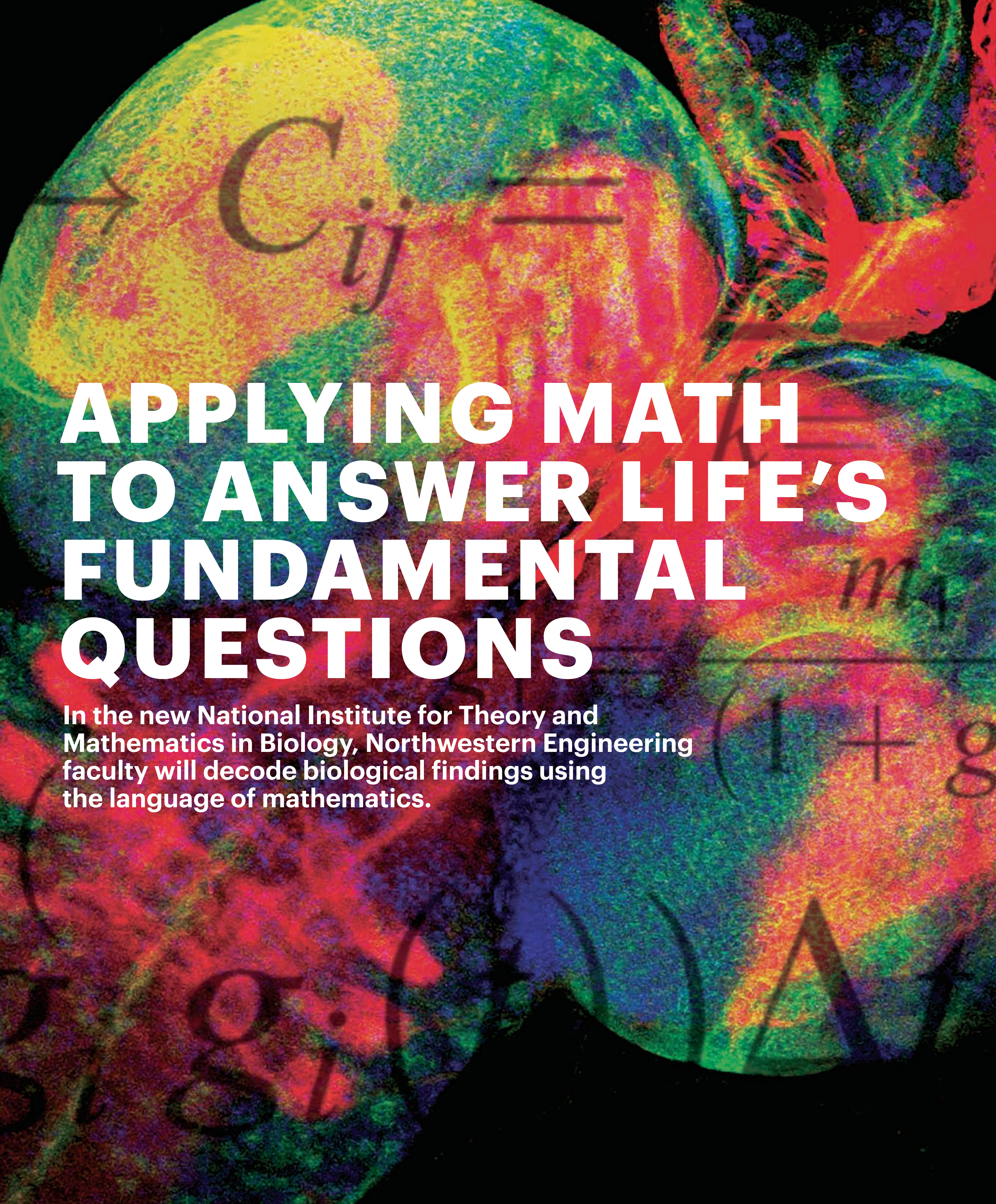
Constructing rain gardens to deliver maximum benefit, however, takes more than just soil, a shovel, and a green thumb. Using machine learning, Northwestern Engineering's Kimberly Gray is working to make sure urban green infrastructure is designed to be ecologically restorative and mitigate climate change.

Gray, Roxelyn and Richard Pepper Family Chair in Civil and Environmental Engineering, and her team collected data on a dozen rain gardens in Evanston. They then compared the rain gardens to natural prairies to identify which characteristics contribute to the best results, taking into consideration biodiversity, pollination, soil quality, weather, and seasons.

"We've taken ecological and chemical data and studied it using machine-learning techniques to identify clusters of the most beneficial areas," Gray says. "We then determined what are the most important attributes that lead to both successful water retention and biodiversity enhancement. In this way we identify when they are most like a natural system, and what causes them to perform differently."

Moving forward, Gray hopes her work will inform and influence the design of green infrastructure networks built by both public and private institutions.

BRIAN SANDALOW



APPLYING MATH TO ANSWER LIFE'S FUNDAMENTAL QUESTIONS

In the new National Institute for Theory and Mathematics in Biology, Northwestern Engineering faculty will decode biological findings using the language of mathematics.

The fruit fly's eye consists of a highly patterned hexagonal lattice of 800 clusters of photoreceptor cells. Some of the secrets as to how this pattern formed remained a mystery until 2022.

That's when an interdisciplinary research team of biologists and applied mathematicians, including Northwestern Engineering's Madhav Mani, associate professor of engineering sciences and applied mathematics, discovered that contrary to what had been hypothesized, the formation of the pattern entails mechanical forces in addition to chemical signals transmitted between cells.

Not only did the breakthrough solve a biological design mystery, it also offered guiding principles that could help scientists understand how patterns form in nature. It could even assist bioengineers in developing synthetic visual sensors.

This and other similar collaborative studies at Northwestern seek to answer some of the most fundamental questions in the life sciences: How are living systems maintained despite uncertain conditions in their ecosystems? How do organisms process information? What drives adaptation and how?

To further such exploration, Northwestern—in partnership with the University of Chicago—established the National Institute for Theory and Mathematics in Biology (NITMB) in September 2023, the only-of-its-kind institute in the United States. Supported by a $50 million grant from the US National Science Foundation (NSF) and the Simons Foundation, the NITMB will discover and develop new mathematics, and bring together mathematical and biological research to uncover the "rules of life" through theories, data-informed mathematical models, and computational and statistical tools.

"Our society is seeing an explosion in both the types and amounts of new experimental data being collected concerning biological systems," says William Kath, Margaret B. Fuller Boos Professor, professor of engineering sciences and applied mathematics, and NITMB deputy director of outreach. "Mathematical theory has been tremendously successful in finding unifying principles and tools with which to understand physical and engineering fields. The goal of the NITMB is to provide a focal point for this to occur with biology."

Applied mathematicians as translators

Helping realize NITMB's goal will be faculty from Northwestern Engineering's Department of Engineering Sciences and Applied Mathematics (ESAM), including Kath, Mani, Niall Mangan, Hermann Riecke, Daniel Abrams, and David Chopp. The group members are accustomed to applying their mathematical expertise to bring scientific clarity to questions across a breadth of subjects, from microscopic active matter to materials to synthetic biology.

"If mathematics is the language, then we aspire to be the translators," Kath says. "We pride ourselves on using mathematics to help people in different disciplines understand what their experiments are showing them. We either adapt existing methods that have been used in other fields, or we help create new mathematical methods that can be used to increase that understanding."

The department's affinity with biology is nothing new. ESAM faculty have been integral in Northwestern's successful NSF-Simons Center for Quantitative Biology (CQuB), established in 2018 within the Weinberg College of Arts and Sciences. Since then, the center has yielded scientific successes and a robust research community.

NITMB will build on CQuB's foundation. Housed on the 35th floor of 875 North Michigan Avenue (the former John Hancock Center) in downtown Chicago, the institute will foster new partnerships and an international reach, host workshops and conferences, and support education initiatives with schools and community partners.

NITMB will also embrace a broader scientific vision initially focused on five research themes:

1. Fidelity and variation. Understanding how living systems are maintained with a high degree of fidelity while being able to vary, adapt, and evolve.

2. Fitness and optimization. Understanding how physical, chemical, and biological constraints shape the capabilities of living systems.

3. Information processing. Developing a quantitative understanding of how living systems optimize information flow in the face of energetic, thermodynamic, and robustness constraints.

4. Learning and adaptation. Shedding light on the mechanisms of biological learning and developing new, biologically inspired machine-learning algorithms.

5. Prediction and anticipation. Investigating the mechanisms that enable anticipation, from simple circadian oscillations anticipating dawn and dusk to sophisticated strategies for optimizing foraging.

Shaping new directions in applied mathematics

Mangan, assistant professor of engineering sciences and applied mathematics and NITMB's theme leader in fitness and optimization, expressed her excitement about the environment at the center, noting, "ESAM has a long track record of interdisciplinary work and building new mathematical techniques that enhance our ability to interpret and therefore impact many applications in science and engineering, including in biology.

"We are excited to expand our research and training programs to become the center of mathematical development to understand biology," she adds. "NITMB will bring together an amazing spectrum of new ideas and up-and-coming scientists who will drive the next generation of research in mathematical biology."

As engineering and biology become more intertwined, Riecke says NITMB presents an opportunity for ESAM to make its mark and stay ahead of the research curve. "It's a natural direction for us to expand into," he says. "It's a big opportunity for us in the ESAM department. The activities of the NITMB and its close interactions between biologists and mathematicians will allow us to identify and shape new directions in applied mathematics. We get to be on the cutting edge of areas in which mathematics is going to make inroads in the future."

BRIAN SANDALOW

INTERNATIONAL EXPERIENCES EXPAND ENGINEERING PERSPECTIVES

NORTHWESTERN ENGINEERING STUDENTS DEEPEN THEIR UNDERSTANDING OF GLOBAL CHALLENGES FIRSTHAND THROUGH LEARNING EXPERIENCES WORLDWIDE.

left PhD student Matthew Sweers reviews a laboratory exercise at JUAMI 2023 in Nairobi, Kenya.

right JUAMI teaches the fundamentals of materials research through hands-on activities.

"I formed friendships and experienced opportunities that have changed my academic, professional, and global perspectives. I am so grateful to have participated in JUAMI."

JENNA TROST Chemical Engineering

PhD student Jenna Trost works with collaborators at JUAMI 2023.

SOMETIMES, getting the best engineering education means leaving campus and stepping out of your comfort zone.

Through immersive learning experiences abroad—as far-reaching as the Atacama Desert in Chile to hospital rooms in Cape Town—Northwestern Engineering students widen their perspectives on global challenges in energy materials, health systems, manufacturing supply chains, sustainability, and water infrastructure.

Bonded by their curiosity to push past the familiar, they deepen their understanding of these challenges, experience other cultures firsthand, forge strong personal connections, and discover fresh ideas, novel approaches, and unexpected opportunities.

JOINT UNDERTAKING FOR AN AFRICAN MATERIALS INSTITUTE

Led by McCormick School of Engineering Professor Sossina Haile, JUAMI fosters collaborations between US-based materials science researchers and their counterparts in Africa through international learning programs.

JUAMI 2023, held in June in Nairobi, Kenya, provided PhD students Matthew Sweers, Jenna Trost, and Dylan Bardgett the opportunity to explore that event's theme, "Materials for Sustainable Energy," with a cohort of international peers who share a passion for global sustainability.

During the two-week program, the students engaged in hands-on laboratory exercises and tutorials and heard from renowned international speakers on electrochemistry, life-cycle analysis, nanomaterials, and solar fuel production. To culminate the experience, they collaborated as part of multinational teams to present high-impact research, outreach, and education proposals.

Sweers, who studies materials science, and his team prototyped JUAMICharz (pronounced JUAMI Cares), an online database of available scientific instruments that could help East African students access the materials characterization tools they need to advance research progress.

"One of the great things about the program is that most attendees have dedicated their careers to research into materials that can help solve our energy and climate crisis," Sweers says. "Given the intelligence and determination of my fellow students, I am positive that many projects will reach successful conclusions."

Trost, who studies chemical engineering, worked with her team of female collaborators from five countries to develop university outreach programs designed to encourage women to pursue STEM fields both in the US and East Africa.

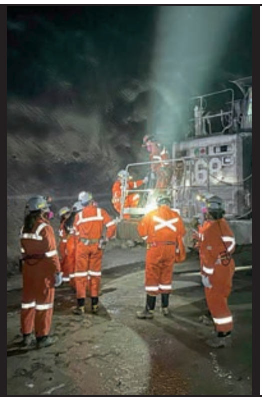
"I formed friendships and experienced opportunities that have changed my academic, professional, and global perspectives," Trost says. "I am so grateful to have participated in JUAMI."

Bardgett, a member of the Haile research group who studies chemistry and helped coordinate the JUAMI lab experiments, realized how some sustainable technologies are more equitable and accessible than others.

"JUAMI helped me realize how important it is to understand the full societal context of whatever scientific problem I am trying to solve," Bardgett says. "I want to do research that would make all of my friends and colleagues from JUAMI proud. To ensure my research is both equitable and accessible, I need to think critically about the problems I'm solving with my research and engage with the communities who will be impacted by my research."

JUAMI is supported by the National Science Foundation and Northwestern's Paula M. Trienens Institute for Sustainability and Energy.

JUAMI 2023 photos by Alexa Erbach, Medill Reports



left Students on the Chile Global Engineering Trek took a funicular up San Cristóbal Hill to experience views of Santiago.

right Students explored an underground copper mine run by the government-owned company Codelco.

Students on the Taiwan Global Engineering Trek toured the Lam Research training center in Hsinchu.

GLOBAL ENGINEERING TREKS

Global Engineering Treks are immersive undergraduate experiences in countries around the world including Chile, China, Israel, Germany, and Taiwan. Lasting nine to 12 days, treks are offered through McCormick Global Initiatives, the Paula M. Trienens Institute for Sustainability and Energy, and other University partners.

CHILE: ENERGY STORAGE & CRITICAL MINERALS

Chile is one of the world's largest lithium and copper producers. It's also a leader in global efforts to build green energy generation and storage systems, accelerate decarbonization initiatives, and invest in renewable resources, such as wind and solar, to power its energy-intensive mining operations.

To better understand this ecosystem, nine students in the Global Engineering Trek in Energy Storage and Critical Minerals visited the country in September 2023. By touring the Sustainable Minerals Institute's International Centre of Excellence, the SQM Lithium extraction facility in the Salar de Atacama salt flat, and El Teniente, an underground copper mine, students found they could better understand the interconnected cultural and economic contexts of minerals mining.

That led mechanical engineering student Penelope De La Torre to refocus her thinking about finite resources and the sustainability of a product's life cycle.

"My concentration is manufacturing, which is dependent on the materials that are mined in Chile and other places around the globe," De La Torre says. "The trek gave me a greater appreciation for the way we get the materials that we use in our daily lives and made me want to dive deeper into both manufacturing more sustainably and also how we can use products in a more sustainable way and create less waste."

TAIWAN: INNOVATION AND HIGH-TECH

For Marisabel Aguilar, a fourth-year student pursuing a bachelor's degree in computer engineering and a Segal Design Certificate, the Global Engineering Trek's inaugural visit to Taiwan was a chance to explore her curiosity about other communities and cultures while learning more about the country's semiconductor, chip, and hardware industries.

The 10-day trip to Taipei and Tainan in June 2023 immersed 15 multidisciplinary Northwestern students in Taiwan's innovation and entrepreneurship ecosystem. The cohort visited semiconductor industry leaders Taiwan Semiconductor Manufacturing Company and Lam Research, toured the Taiwan Tech Arena innovation incubator, and attended research seminars at Academia Sinica and National Tsing Hua University. At National Taiwan University's Human-Computer Interaction Research Lab, the group demoed virtual reality programs and computer games developed by NTU students.

"Many of the companies we visited have offices in the US, and the representatives were very welcoming in encouraging us to look into positions in the US and abroad," says Aguilar.

Aguilar also appreciated the opportunity to connect with the Northwestern cohort, peer students studying in Taiwan, and members of the Northwestern Alumni Club of Taiwan. "We got super lucky with everyone on the trip," Aguilar says. "It felt like a big family."

A joint initiative with Northwestern's Office of the Vice President for International Relations, the Global Engineering Trek in Innovation and High-Tech was generously supported by the Ministry of Foreign Affairs in Taiwan and the Friends of Taiwan Foundation.

Students in the Global Healthcare Technologies in South Africa program toured the Garden Route on the southeastern coast of South Africa.

> **"I learned a lot about myself. The experience made me more confident in my decision to pursue software engineering."**
>
> **SHUBHANSHI GAUDANI** Computer Science

GLOBAL HEALTHCARE TECHNOLOGIES IN SOUTH AFRICA

During the winter 2024 quarter, 15 Northwestern Engineering students joined the Global Healthcare Technologies in South Africa program, collaborating with faculty members from Northwestern, University of Cape Town, and Stellenbosch University to develop point-of-care medical technologies and methodologies to improve health outcomes in the townships of Cape Town. Past diagnostic and therapeutic innovations include a phototherapy blanket to treat jaundice in neonates, a digital x-ray system, and a specimen cup to test for tuberculosis.

Organized by Northwestern Engineering's Center for Innovation in Global Health Technologies and Northwestern's Global Learning Office, the program included a four-course Northwestern curriculum emphasizing problem definition, user-centered solutions, and the principles and practice of medical device design. Through site visits to Cape Town hospitals, students learned firsthand the challenges of cost-effective healthcare delivery in developing countries and the disease burden in resource-constrained health systems.

Anika Gupta, a fourth-year student pursuing combined bachelor's degrees in biomedical engineering and global health studies and a master's degree in chemical and biological engineering, worked with faculty at Stellenbosch University to analyze barriers in the medical device innovation process in South Africa and developed approaches to overcome these obstacles.

The ability to study abroad while fulfilling requirements for both her majors was a key factor in Gupta's decision to choose Northwestern.

"I am interested in learning about cultures and healthcare systems around the world and how innovation can make healthcare more widely effective and accessible," Gupta says. "I've realized that more international collaboration could really help with creating a healthcare system that equitably benefits and serves people."

COMPUTER SCIENCE ABROAD

Shubhanshi Gaudani was one of 23 Northwestern Engineering computer science undergraduate students who studied at institutions around the world in fall 2023, including ETH Zürich in Switzerland, National Taiwan University, Universidad Carlos III de Madrid, University of Edinburgh, and Yonsei University in Seoul.

During her quarter at ETH Zürich, Gaudani completed graduate-level courses in object-oriented programming, natural language processing, and advanced topics in communication networks. She found ETH Zürich's theoretical approach to curriculum in stark contrast to her Northwestern computer science studies.

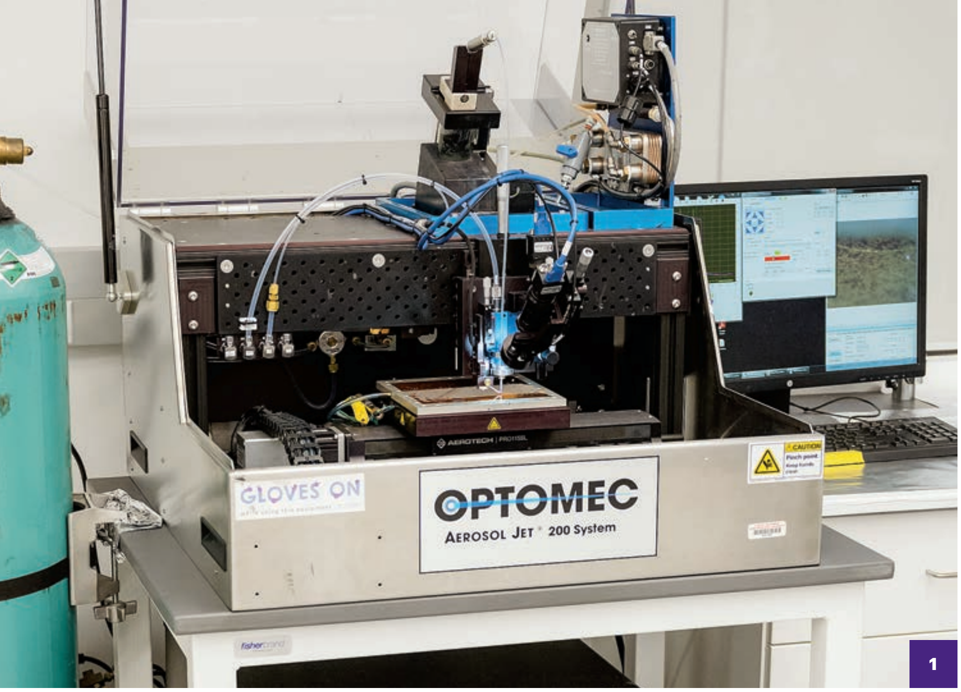
"Northwestern has a more hands-on, coding-focused, practical approach, whereas ETH classes focused more on mathematical theorems, proofs, and concrete reasoning," Gaudani says.

An avid hiker, Gaudani formed a travel group to organize weekend travel, including an Interrail train trip to Finland to view the northern lights. As part of an applied glaciology course, Gaudani also joined an excursion to the research station at the glacier saddle Jungfraujoch.

The bonds Gaudani built with other computer science students gave her confidence about her career pathway.

"I learned a lot about myself. The experience made me more confident in my decision to pursue software engineering," Gaudani says. "Several of us were going through the same recruitment cycle for post-graduate opportunities, jobs, or internships. We were all going through similar struggles, so I felt supported."

MICHELLE MOHNEY



1

LAB TOUR
MATERIALS INNOVATION LABORATORY

2

Thinking big about small materials, researchers in Northwestern Engineering's Materials Innovation Lab are advancing additive manufacturing at the nanoscale, developing methods to produce sustainable materials and inks that will help build the biosensors, batteries, transistors, and neuromorphic devices of the future.

"The applications for these devices and materials address some of the most significant challenges and opportunities confronting society, from sustainability to next-generation computing to healthcare innovation," says Mark Hersam, Walter P. Murphy Professor of Materials Science and Engineering and chair of the Department of Materials Science and Engineering. "The work done by our students in the Materials Innovation Lab directly reinforces Northwestern Engineering's leadership in materials science."

Located on the fourth floor of Mudd Hall, the Materials Innovation Lab opened in fall 2023 and includes an array of advanced printing and battery testing technologies.

1. OPTOMEC AEROSOL-JET PRINTER
This aerosol-jet printer aerosolizes functional nanomaterial inks and deposits them onto a substrate using a carrier gas. This contactless, digitally programmable technique enables high-resolution patterning of a wide range of nanomaterials onto an array of surfaces, making it a valuable prototyping tool for printed electronics.

2. AUTOMATED SCREEN PRINTER This automated screen printer helps researchers print thin and flexible electronic devices, including batteries and sensors. Similar to the process used to screen-print T-shirts, the printer deposits and presses different electronic materials through a stencil to build devices layer by layer. This instrument is key to the lab's efforts to scale up its production to larger quantities, as it offers rapid printing speeds, large-area coverage, and high resolution.

Tour the Materials Innovation Lab
View the lab's devices in action and learn from students how these technologies support research.

Photos by Jason Brown

3. METAL-ORGANIC CHEMICAL VAPOR DEPOSITION Metal-Organic Chemical Vapor Deposition (MOCVD) is a workhorse system for growing monolayer atomically thin films, specifically semiconducting, wafer-scale materials used in neuromorphic computing and quantum information science. Capable of reaching 1,100 degrees Celsius, MOCVD functions as a high-temperature, controlled-atmosphere oven.

The MOCVD variables can be tuned precisely to create a chemical environment that ensures that the atomically thin films grown in the lab possess desirable crystallinity and electronic properties. Stephanie Liu, a PhD student in the Hersam lab, says, "Ultimately, we want to know—can we still create great quality films at lower temperatures that use less energy?"

4. BATTERY MEASUREMENT STATION The lab's battery cycler is used to continuously charge and discharge prototype batteries that could eventually be used in applications such as powering electric vehicles or supporting the electrical grid. The system measures the longevity of the lab's electrodes and electrolytes that utilize nanoscale composite materials. While some tests are completed within a few hours, other tests focused on long-term performance can take several months. Optimizing electrochemical energy storage, especially in batteries, is a critical component in the transition away from a fossil-fuel-based economy.

5. FUJIFILM DIMATIX MATERIALS PRINTER This inkjet printer supports research and development as well as feasibility testing by transforming digital designs into physical prototypes. It seamlessly and precisely deposits ink droplets onto surfaces found in flexible electronics, optoelectronics, and sensors.

When used in tandem, the lab's three printers can print material layers at different length scales to build complex devices.

ALEX GERAGE

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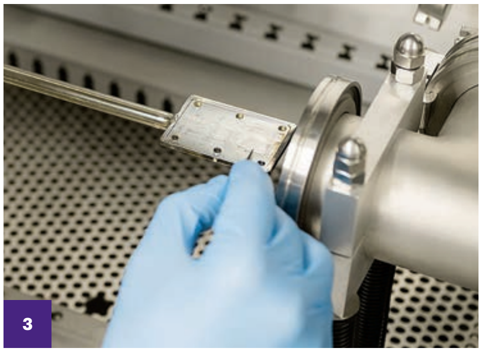
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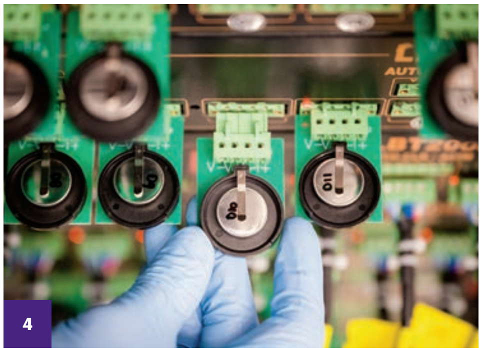
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CLASS NOTES

A Process of Discovery

DAVID HINTON TURNED HIS CHEMICAL ENGINEERING STUDIES INTO A 22-YEAR INVESTMENT CAREER

David Hinton ('95) acknowledges that his 22-year career in the investment field with Boston Partners represents an odd turn for a chemical engineering major.

Dig deeper into Hinton's backstory, however, and his move from studying thermodynamics, fluid mechanics, and energy transfer to making buy, sell, or hold recommendations isn't as far-fetched as it might seem initially.

After all, Hinton, a Cleveland native drawn to Northwestern by its strong academics, Big Ten status, and Midwestern location, had planned on majoring in economics until a high school teacher, recognizing his aptitude in math and science, encouraged him to explore engineering.

Once at Northwestern, Hinton enjoyed discovering in his engineering courses how to research, create, and refine processes. Ultimately though, he didn't see himself pursuing chemical engineering's traditional paths in process- and plant-support roles. Instead, he envisioned himself in the business world, perhaps working his way through investment banking and private equity before someday running companies.

Lively, inspired conversations with his adviser, chemical engineering professor Julio M. Ottino, helped Hinton realize his undergraduate studies and professional ambitions were closer to each other than he imagined. As Ottino spoke about marrying left-brain analytical skills with right-brain creativity—a prelude to the whole-brain engineering mindset Ottino would champion as dean of Northwestern Engineering from 2005 to 2023—Hinton felt empowered and confident.

"Things aren't always in a straight line," he says. "I began to see that the problem-solving and analytical skills I was gaining as a chemical engineering student would be invaluable in any profession I'd choose."

And while Hinton's professional career began in more traditional engineering roles—first in environmental engineering, designing wastewater treatment plants and waste remediation systems, followed by a stint at LTV Steel Co.—it wasn't long before he pursued his business ambitions. He earned an MBA from the Tuck School of Business at Dartmouth College and joined Boston Partners in 2002 as an equity analyst, eventually covering the media, utilities, and insurance industries before joining the firm's small cap strategy team in 2007.

Today, Hinton is into his third decade as an equity analyst at Boston Partners, where the meritocracy of investing provides energizing challenges. Focused on creating informative analyses of small-cap stocks, Hinton's work includes conducting fundamental research on companies, investigating financial statements, interviewing industry experts, and summoning his chemical engineering background to deconstruct business operations.

"I believe there are some insights that I have over the average investor because I've been in the plant and watched manufacturing up close," he says.

Appreciative of his Northwestern experience, Hinton currently serves as chair of the Murphy Society, the McCormick School of Engineering alumni group that helps shape the school's education and research priorities by advising the dean on special project funding decisions.

"I'm very loyal to Northwestern and value the opportunity to give my time to help move the school forward," Hinton says. "It's exciting to interact with alumni and leadership and know Northwestern remains as ambitious as ever."

DANIEL P. SMITH

LEARNING WHAT DESIGN *REALLY* MEANS

APPLYING THE DESIGN THINKING SHE DEVELOPED AT NORTHWESTERN, **HANNAH CHUNG** HAS BUILT AN ENTERPRISING PROFESSIONAL LIFE CENTERED AROUND SOCIAL GOOD.

Before entering Northwestern Engineering as a first-year student in 2008, Hannah Chung ('12) assumed design "was all about making things pretty."

After her first year in Evanston, Chung had discovered the truth, illuminated by faculty mentors such as Jeanne Herrick and Walter Herbst: Design was less about aesthetics and more about creative problem-solving. "I realized I could apply my creativity not just to form or function, but to systems, collaborations, and strategy," Chung says.

Inspired by that realization, Chung, a mechanical engineering major with a design concentration, immersed herself in design courses and independent study, blending analysis, logic, and math with intuition, emotional intelligence, and imagination. Exploring engineering and design simultaneously empowered Chung, ignited her imagination, and spurred numerous entrepreneurial pursuits.

In 2009, Chung teamed with Professor Elizabeth Gerber and two fellow Northwestern undergraduates to launch Design for America (DFA). DFA gathered students from across disciplines and challenged them to address complex problems through human-centered design. The DFA studio model has since been exported to dozens of universities throughout the United States.

"The idea of bringing students from diverse backgrounds together for the purpose of creating social impact is well known now, and it's amazing to think we had a hand in bringing about this cultural shift," Chung says.

Through DFA, Chung and a fellow Northwestern graduate founded Sproutel, a company that creates interactive experiences for kids with health issues. When Sproutel landed a spot in a Rhode Island-based business accelerator, Chung designed her own virtual education program, a rather novel learning approach in the pre-pandemic era. With the blessing of Northwestern administration, Chung completed her final academic quarter via Skype—graduating early from Northwestern and completing the business incubator the same week in spring 2012.

Thereafter, Chung devoted herself fully to driving Sproutel's evolution, enduring the inevitable ebbs and flows of the startup world, from building a team to refining processes to developing products rooted in human-centered design. Chung estimates she interviewed more than 1,000 relatives of patients to gain a better understanding of context and to formulate relevant solutions ranging from an interactive teddy bear that educated kids about diabetes to a robotic duck that provided emotional support to children undergoing chemotherapy.

"The way we interacted with children and worked to understand them really powered us and our business growth," Chung says.

In June 2020, Chung left Sproutel to seek new professional adventures. She began teaching at the Rhode Island School of Design and advising nonprofits and startups. While design remained integral to her work, she hungered for a return to more direct applications. In particular, she wanted to deliver a richer storytelling experience—something she considers vital to human-centered design—through more accessible products.

So, Chung set off to become an author and illustrator of children's books with positive, encouraging messages. Her debut title, *The Most Perfect Persimmon*, will be published in fall 2024.

"I remain on the beautiful path I started at Northwestern and am continuing to use design for social good," Chung says.

DANIEL P. SMITH

OPENING THE WAY TO A FUTURE IN ENGINEERING

Engineering Tomorrow founder **Bill Woodburn** helps underserved high school students discover their potential for a career in engineering by introducing them to STEM subjects.

Bill Woodburn (MS ’75) grew up in a lower-income area of Queens, New York, where higher education seemed a world away.

“I had two great parents, but we didn’t have any money,” he remembers. “No one went to college in my family. We didn’t have any discussions about academics or careers growing up; we were pretty much just living day to day.”

A basketball coach noticed that Woodburn excelled in math and science and introduced him to the United States Merchant Marine Academy. That’s when Woodburn began to see higher education as an option. “There were two curriculums—engineering and marine science,” he says. “I thought with my math and science interests, engineering sounded better. So, it was all luck. It was a matter of the stars and moon aligning.”

Woodburn went on to earn a master’s degree in environmental engineering at Northwestern. Recognizing how fortunate he was to get a great education despite his circumstances growing up, he gives back by helping students from lower-income neighborhoods and underrepresented groups discover engineering. In 2014, he founded Engineering Tomorrow, a nonprofit organization that introduces high school students to engineering and other STEM careers.

Engineering Tomorrow provides hands-on instruction, virtual labs, and mentorship to students, teachers, and schools at no cost. What began with Woodburn teaching water purification experiments in school gyms has scaled rapidly: 400,000 students are expected to participate in virtual labs in every state in the country this year.

“There’s a lot of talent that needs some direction, some mentorship, some idea of what’s out there,” he says. “It’s good for America’s competitiveness to have more engineers and to increase diversity in the field, and it’s good for these kids to have a chance in life.”

"IT'S GOOD FOR AMERICA'S COMPETITIVENESS TO HAVE MORE ENGINEERS AND TO INCREASE DIVERSITY IN THE FIELD, AND IT'S GOOD FOR THESE KIDS TO HAVE A CHANCE IN LIFE."

Encouraging engineering thinking

The labs have real-world applications, including a biomedical engineering lab that uses phototherapy to address Grover's disease, a dermatological condition that causes rashes.

After Woodburn contracted the disease and received ineffective treatments, he studied research on improving the immune system using specific wavelengths of sunlight. He designed a device to simulate a wavelength of sunlight that enhances immune response levels and treats the disease's symptoms.

Woodburn patented the process, and clinical research at Northwestern Memorial Hospital confirmed successful results in an initial trial. "I was able to address my skin condition by following the principles of engineering," he says. Now the process he went through is part of the Engineering Tomorrow curriculum.

Woodburn hopes Engineering Tomorrow will help create a diverse workforce for solving the engineering challenges of the future. He wants to give students the mentorship he lacked by showing them how creative the field of engineering can be and the tremendous impact it can have.

"It's a rewarding profession that I just love," he shares. "It opened up so many opportunities for me. That's why I founded Engineering Tomorrow, to give others the same opportunities."

Building a remarkable career

A former McCormick Advisory Council member, Woodburn appreciates the advantage Northwestern gave him in his career. "I had a fantastic graduate engineering program. It was tough and demanding, but I liked it," he says.

Woodburn has applied the engineering lessons he learned at Northwestern throughout his career. He started as an engineer with Union Carbide Corporation before joining McKinsey & Company, where he worked on transportation, refinery, and natural gas projects. He was then recruited by General Electric, where he served in different locations around the world before becoming president and CEO of GE Infrastructure, overseeing key acquisitions for the company's entry into the water technology business. In 2023, his career and contributions to the field were honored with his election to the National Academy of Engineering.

Sticking to the fundamentals

After 23 years with GE, at a time Woodburn had planned to retire, he was introduced to several people involved in establishing Global Infrastructure Partners, an independent infrastructure investment firm. Founded in 2006, GIP manages approximately $100 billion on behalf of its global investors, specializing in the energy, transportation, and water and waste sectors. As founding and operating partner, Woodburn optimizes processes and streamlines operations for the businesses GIP runs.

The firm is transitioning into a new phase with a $12.5 billion deal for BlackRock to purchase GIP, making it the world's second-largest infrastructure investor. What began as an interesting opportunity became a major success, thanks in part to Woodburn's engineering expertise.

"I was very focused on the efficiency of capital spending, cycle time, and the speed at which we executed," he says. "These are engineering techniques that are all about optimizing processes, whether it's coordinating arriving and departing aircraft and moving people through security and immigration or moving containers on and off ships and loading them onto trucks. I have stuck to the fundamental principles of engineering and physics, and I've been analytical the whole way."

SARA LANGEN

IN MEMORIAM

Gordon Murphy

Warren Haug

PROFESSOR EMERITUS GORDON MURPHY

Gordon Murphy, professor emeritus of electrical engineering and computer engineering and of computer science, passed away at age 96 on November 26, 2023.

Murphy joined Northwestern Engineering in 1957 as an associate professor of electrical engineering. Three years later, he was promoted to professor of electrical engineering and served as chair of the department from 1960 to 1969. After 40 years of service to the University, Murphy retired in 1997.

"Gordon had a long and distinguished career at ECE," says Randall Berry, John A. Dever Chair of Electrical and Computer Engineering. "He had an impressive range of interests and contributed greatly to the department."

Murphy earned a PhD in electrical engineering with a minor in mathematics from the University of Minnesota in 1956, an MS in electrical engineering from the University of Wisconsin in 1952, and a BS in electrical engineering from the Milwaukee School of Engineering in 1949.

He conducted research in automatic control, electronic systems, and digital computers. In 1968, he initiated a program of research and development that culminated in the design, development, and commercialization of a line of electric vehicles. He and his collaborators secured six patents in television, consumer products, motion control, and electronic dental instruments.

"Gordon was committed to teaching the complete process of electrical and computer engineering design," says Alan V. Sahakian, professor of electrical and computer engineering. "Students taking his capstone courses learned through doing, from circuit design to coding to printed-circuit-board layout to debugging. He was an early expert in embedded systems design and worked with industry to see the best modern practices and then brought these into the classroom and teaching labs."

WARREN HAUG (MS '63, PhD '65)

Alumnus and former adjunct professor and McCormick Advisory Council member Warren Haug passed away at age 85 on October 30, 2023.

Haug earned both his master's and doctoral degrees in chemical engineering from Northwestern Engineering before embarking on a 30-year career in research at the Procter & Gamble Company. While serving on the McCormick Advisory Council, Haug joined the McCormick School of Engineering as an adjunct professor. For 15 years, Warren taught two courses: one focusing on personal and organizational effectiveness and the other on management and metrics of product development. He received several awards for teaching and delivered two commencement addresses.

Thomas C. Gallanis '50, '52
Robert L. Daileader '51
Craig W. Hammill '51
Karl R. Schroeder '51
James H. Wear '51, '62
Thomas H. Brinkmann '52
Robert B. Clarke '53, '54
David M. MacMillin '53
John R. Strieter '53
Paul R. Lagerlof '54
Walter T. Brownell Jr. '55
Richard W. Rausch '55
Floyd B. Shacklock '55
Kenneth J. Sliwa '55
Robert A. Moore '56, '60
Frank J. Murphy '57
Roger A. Rydin '57
William S. Groenier '58, '59
David W. Lewis '58
Andrew U. Meyer '58, '61
Eugene M. Chodash '59
William Gapp '59, '60, '66
Nicholas F. King '59
David O. Rickson '59
William P. Allman '60, '66
Charles H. Brintlinger '60
Frederick J. Clarke '60
Philip H. Graham '60
Irving Liberman '60, '65
David A. Thompson '61
George L. Vinnedge '61
Paul A. Anderson '62
Martin P. Daly '63
Helmut J. Haas '63
Edward G. Sheppard Jr. '63
David F. Ollis '64
Subhash C. Anand '65, '68
Stanley A. Wulf '65
G. Wayne Dietrich '66, '73
Farrokh N. Screwvala '67
Robert L. Stright '67
Donald J. Coppin '68
Frank T. James '68
Roger T. Ward '68, '70
Robert T. Lentz '69
Layne Doran Anderson '70, '72
Terrence L. Burch '70
C. Craig Hedberg '70
Janet E. Meyer '71
Donald A. Grote '74
Robert F. Vanderhorst '75
Maureen Barry Girkins '76, '79, '88
Bruce Larry Wilkoff '76
Albert Elgar Jr. '78
John W. Bumgarner '80
Michael R. Ordun '80
David B. Boss '81
Christopher M. Cavan '86
Richard R. Wallace '86
Kitt E. Douglas '87
Michael Leo Lakhovsky '01
Raymond P. O'Leary '01
Alexis Ann Williams '02
Jorge Sanchez-Ferrer '04

BIG IDEA

JUST HOW OLD IS THE MOON?

More than 4 billion years ago, a giant Mars-sized object crashed into Earth. A colossal hunk broke off to form the Moon, and the energy of the impact melted the rock that eventually became the Moon's surface.

Some previous assessments estimated the age of the Moon at 4.42 billion years. A new study, which analyzed tiny lunar crystals gathered in 1972 by Apollo 17 astronauts, showed that estimate was wrong. The new study found that the Moon is actually 4.46 billion years old—40 million years older than previously thought.

Led by researchers at Chicago's Field Museum and the University of Glasgow, the study was made possible by Northwestern University's Center for Atom-Probe Tomography, which nailed down the age of the oldest crystal in the sample.

Northwestern's Dieter Isheim, research associate professor, and David Seidman, Walter P. Murphy Professor Emeritus of Materials Science and Engineering and founding director of the center, analyzed zircon crystals hidden within dust collected from the Moon. After determining the makeup of the materials in the sample and performing radiometric dating, researchers pieced together the revised timeline of the Moon's formation.

Photo by NASA

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Expanding Horizons

In February, Northwestern Engineering welcomed Chicago-area middle school and high school girls to its 53rd annual Career Day for Girls, hosted by the Northwestern undergraduate student chapter of the Society of Women Engineers. The day's programming—inspired by the theme "Reach for the Stars!"—featured hands-on activities, career-focused panel discussions, and lab tours throughout the Technological Institute. Among the stops was the Center for Robotics and Biosystems, where attendees watched a demonstration of swarm robotics.

Photo by Jason Brown