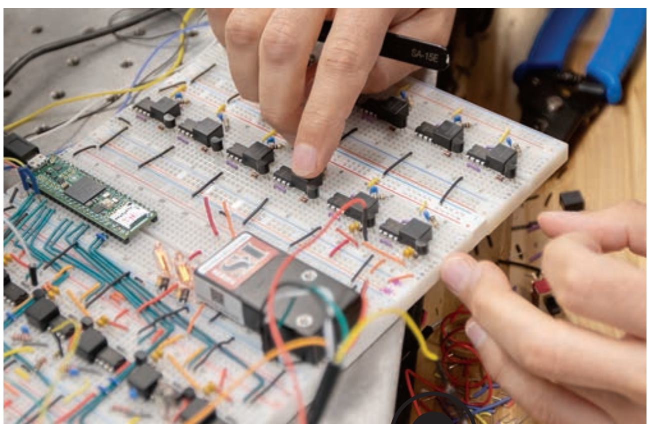
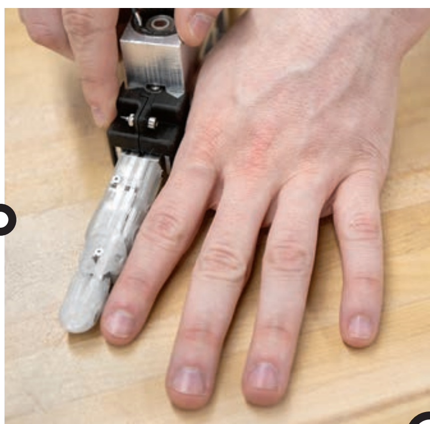
McCormick School of Engineering and Applied Science

NORTHWESTERN ENGINEERING

SPRING 2025

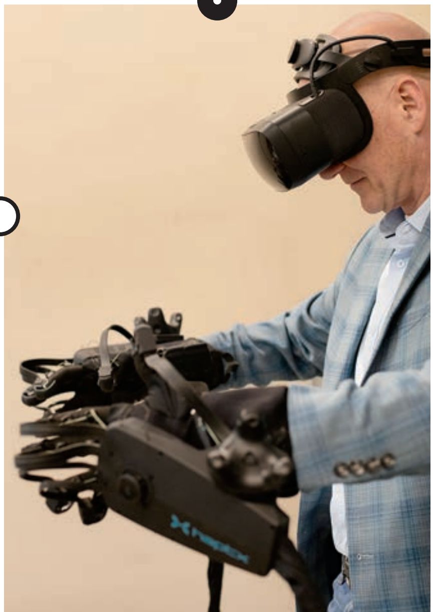
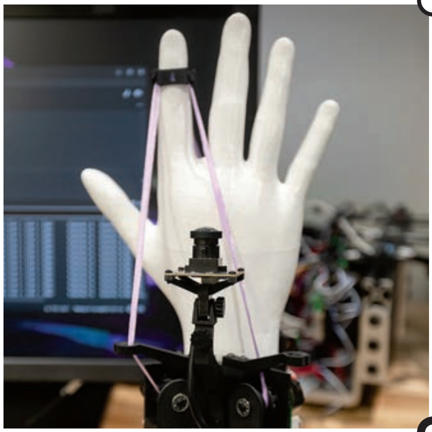



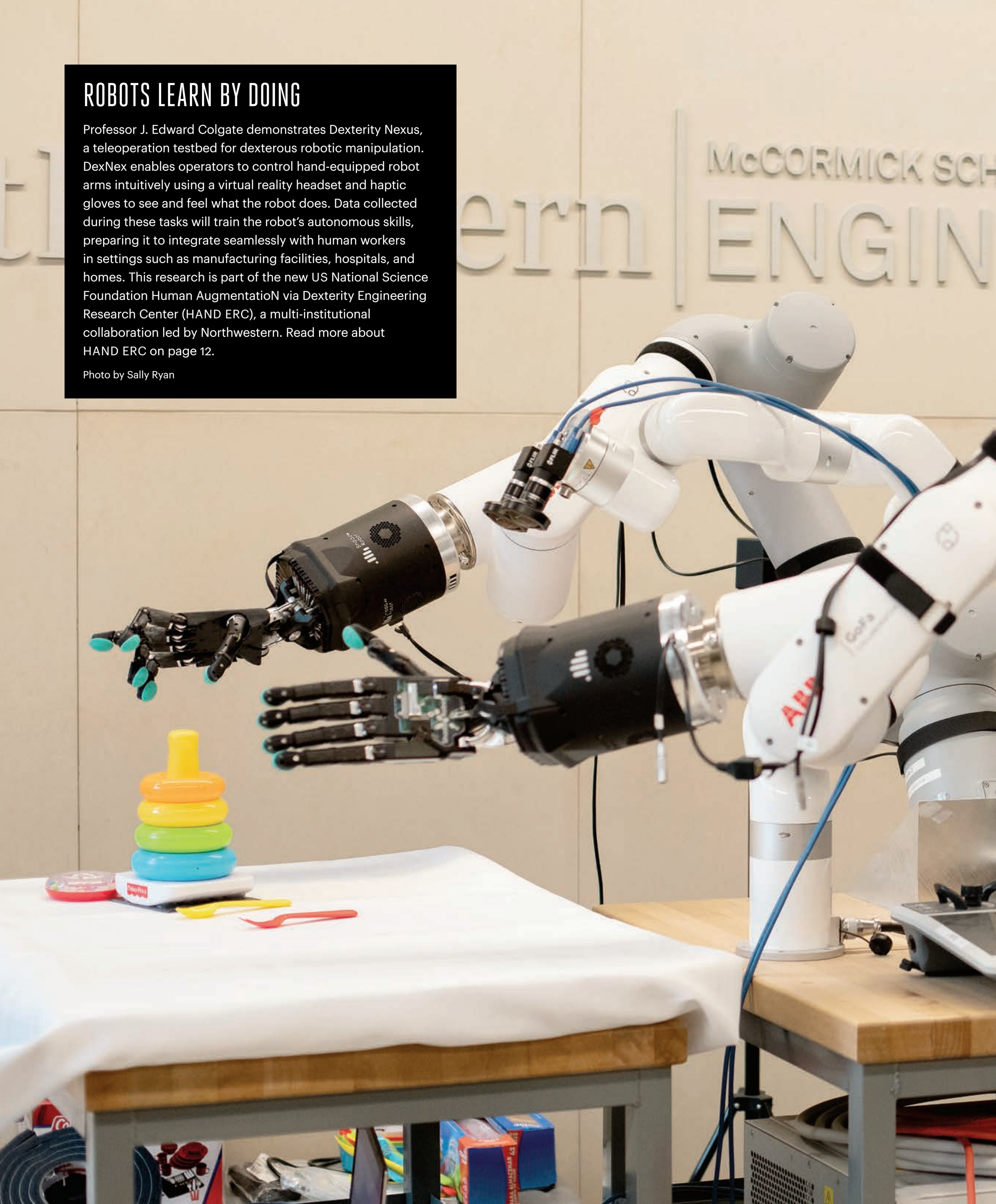




ALL HANDS ON DECK

REVOLUTIONIZING MANUFACTURING, CAREGIVING, AND MORE WITH DEXTEROUS ROBOT HANDS



ROBOTS LEARN BY DOING

Professor J. Edward Colgate demonstrates Dexterity Nexus, a teleoperation testbed for dexterous robotic manipulation. DexNex enables operators to control hand-equipped robot arms intuitively using a virtual reality headset and haptic gloves to see and feel what the robot does. Data collected during these tasks will train the robot's autonomous skills, preparing it to integrate seamlessly with human workers in settings such as manufacturing facilities, hospitals, and homes. This research is part of the new US National Science Foundation Human AugmentatioN via Dexterity Engineering Research Center (HAND ERC), a multi-institutional collaboration led by Northwestern. Read more about HAND ERC on page 12.

Photo by Sally Ryan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Engineers thrive in times of rapid change, and our work is as important as ever. I have no doubt that our entire community will come together to chart a path forward that advances our work while staying true to our mission that has guided our institution for generations.

GREETINGS FROM NORTHWESTERN ENGINEERING

As I write this in early May, we are at a difficult moment for our research enterprise. As has been widely reported, a significant portion of Northwestern's federally funded research is subject to stop work orders. This research is a critical part of our dual mission—we bring together the best minds from around the world for both education and the development of new knowledge that moves society forward.

As we navigate this environment, sharing the impact of what happens inside our laboratories and our classrooms has taken on new importance. Our work drives an ever-increasing research portfolio that benefits our safety and security, health and wellness, and economic prosperity.

This issue of our magazine highlights just a small sample of projects that are advancing their fields in ways that will better society. Researchers in our new US National Science Foundation Human AugmentatioN via Dexterity Engineering Research Center (HAND ERC) are working to develop dexterous, intelligent robot hands that can assist humans with manufacturing and caregiving. Northwestern has a long history of innovation in robotics, and this multi-institutional collaboration will build on those successes to advance hardware, augment robot learning with embodied AI, and move that new technology out into the world.

As we build new systems that assist us, our faculty are also developing new biohybrid devices that can be integrated within us to treat disease and optimize performance. These materials, patches, and implants are on the leading edge of healthcare and are the result of engineering feats in materials science, mechanics, and electronics.

Both robotics and biohybrid systems have the potential to greatly impact our society—but we are also working to solve problems that have a big impact locally. Our first-year Design Thinking and Communication students partner with local businesses, non-profits, and individuals to learn design thinking, tackle unique problems, and come up with innovative ideas—such as a better microwave interface for adults with developmental disabilities and a redesigned carrying case for occupational therapists' devices.

We remain deeply committed to advancing engineering research and educating the next generation of talent who will continue our long legacy of impact. Engineers thrive in times of rapid change, and our work is as important as ever. I have no doubt that our entire community will come together to chart a path forward that advances our work while staying true to our mission that has guided our institution for generations. I am grateful for your continued support and partnership.

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

On the Cover
Northwestern engineers in the new US National Science Foundation Human AugmentatioN via Dexterity Engineering Research Center (HAND ERC) are developing dexterous, intelligent robot hands that could one day assist humans with manufacturing, caregiving, and more. See the story on page 12.

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Northwestern | McCORMICK SCHOOL OF ENGINEERING

Executive Director of Strategic Initiatives and Marketing: Kyle Delaney

Editorial Team: Christa Battaglia, Alex Gerage, Brian Sandalow, Michelle Mohney, Emily Ayshford

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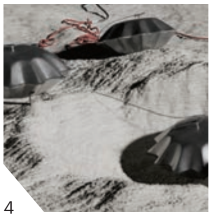
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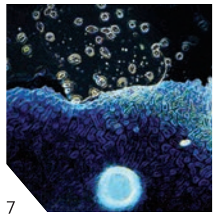
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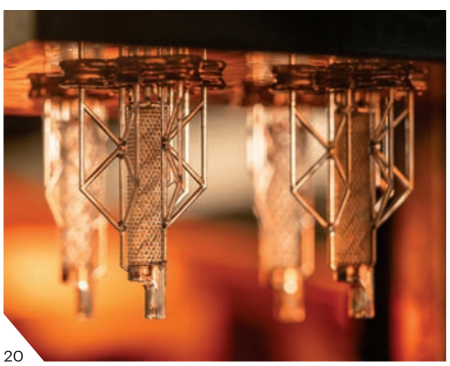
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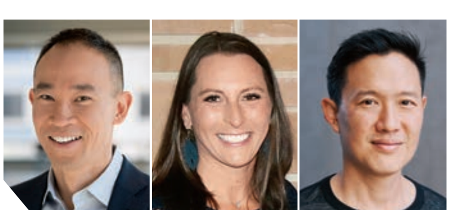
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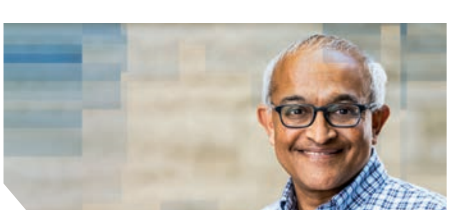
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NORTHWESTERN ENGINEERING
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NEWS

Northwestern to Lead $20 Million National AI Research Institute in Astronomy

A large multi-institutional collaboration, led by Northwestern, received a $20 million grant to develop and apply new AI tools for astrophysics research and deep-space exploration.

Jointly funded by the US National Science Foundation and the Simons Foundation, the highly competitive grant established the NSF-Simons AI Institute for the Sky (SkAI, pronounced "sky"). Northwestern astrophysicist Vicky Kalogera is principal investigator of the grant and will serve as the director of SkAI. Northwestern Engineering's Aggelos Katsaggelos, an AI expert, is a coprincipal investigator.

The new institute will unite multidisciplinary researchers in developing innovative, trustworthy AI tools to analyze large astronomy datasets, transform physics-based simulations, and more in their pursuit of breakthrough discoveries. With unprecedentedly large sky surveys poised to launch, including from the Vera C. Rubin Observatory in Chile, astronomers will require smarter, more efficient tools to accelerate the mining and interpretation of increasingly large datasets. SkAI will fulfill a crucial role in developing and refining these tools. Centrally located in Chicago, SkAI will unite 83 team members from 25 partner organizations.

- The new institute will unite multidisciplinary researchers to develop innovative, trustworthy AI tools for astronomy.
- Jointly funded by the National Science Foundation and the Simons Foundation
- The institute includes 14 faculty members from the Weinberg College of Arts and Sciences and the McCormick School of Engineering.

10 Times more resistant to decomposition that a new solar cell coating developed by Professors Ted Sargent and Bin Chen is compared to conventional coatings

59 Undergraduate and graduate students who participated in the IQ-PARC Quantum Summer School

New Partnership Aims to Accelerate Tech Commercialization

Northwestern's Querrey InQbation Lab (The Q) entered a partnership with Material Impact, a Boston-based venture firm focused on innovations in materials science and deep tech.

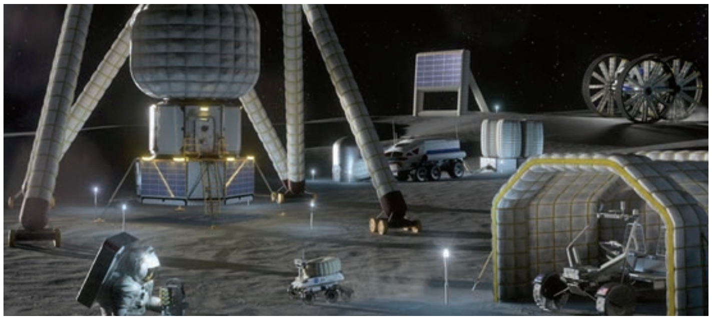
Launched in 2021 with funding from the State of Illinois and a generous gift from Northwestern Trustee Kimberly Querrey, The Q serves as the University's hub for research-driven entrepreneurship with space, programming, and resources to translate Northwestern's research and development into commercial applications.

As a part of the collaboration, members from Material Impact will join committees, mentor entrepreneurial residents, and advise fellows on projects.

HANDS-ON COURSE PREPARES FIRST-YEAR STUDENTS TO TACKLE GLOBAL ENERGY CHALLENGES

First-year Northwestern Engineering students are diving into the future of sustainability thanks to a unique course that brings energy materials to life. Taught by Assistant Professor Raj Kumar, MatSci 195: Materials for the Energy Solution is a hands-on class that teaches students how to tackle global energy challenges.

The course introduces students to modern and emerging energy materials such as lithium-ion batteries and perovskite solar cells. Instruction emphasizes how these materials store and harvest energy and offers a glimpse into how materials scientists and engineers work to design better batteries and solar cells.



STUDENT TEAM WINS HIGHEST HONOR AT NASA BIG IDEA CHALLENGE

A team that included 25 Northwestern Engineering students took the highest honor at NASA's 2024 annual Breakthrough, Innovative, and Game-Changing (BIG) Idea Challenge forum last November.

The interdisciplinary group claimed the Artemis Award given to the team whose concept has the greatest potential to contribute to NASA's future Artemis moon missions. The challenge's theme, "Inflatable Systems for Lunar Operations," required teams of students and their faculty advisers to go beyond inflatable habitats to explore other innovative concepts incorporating inflatable components such as deployable towers, soft robotics, low-mass cranes and gantries, large antennas and solar reflectors, and emergency shelters.

The Northwestern team proposed a metal inflatable system made by laser-welding stacked layers of sheet metal along their aligned edges. Once on the lunar surface, pressurization would deploy gantries, solar towers, and other structures from rolled, folded, or origami-like stowed configurations.

The team was managed by student leads Trevor Abbott (mechanical engineering), Julián Rocher (mechanical engineering), and Ben Taalman (materials science and engineering), with Victoria Israel (mechanical engineering) and Gavin Chung (mechanical engineering) serving as interim team leads. Professors Ian McCue and Ryan Truby served as advisers.

The interdisciplinary group won the Artemis Award given to the team whose concept has the best potential to contribute to NASA's future Artemis moon missions.

"THIS WAS THE ULTIMATE TEAM EFFORT, AND TOGETHER, WE BROUGHT THE COVETED ARTEMIS AWARD HOME."

Trevor Abbott Mechanical Engineering

The team proposed a metal inflatable system made by laser-welding stacked layers of sheet metal along their aligned edges.

Global Trek Students Explore Chile's Role in Green Energy

Eight students, including five from Northwestern Engineering, journeyed to Chile in September 2024 for the Center for Engineering Sustainability and Resilience's second Global Engineering Trek: Energy Storage and Critical Materials.

The trek aimed to show students firsthand how industry and green technologies impact local communities. Central to the experience were visits to three Chilean mines, including the Mantoverde copper mine in Copiapó, about 500 miles north of the trip's base in Santiago, the country's capital city.

During that excursion, the students ate lunch with the miners and experienced part of their daily life. They observed a constant stream of massive mining vehicles carting away ore. They also visited SQM's lithium mine in the Atacama Desert and learned about efforts to conserve water.

Beyond the tours, the group met with Chilean professors and students, visited cultural landmarks, and attended a "La Semana de la Chilenidad" celebration that commemorated the country's independence.

- Up to $56 million has been awarded by the federal Advanced Research Projects Agency for Health.
- The VISION team consists of 40 scientists, medical doctors, and industry experts from across the United States, including the McCormick School of Engineering's Hao Zhang and Cheng Sun.

"CLOSE COLLABORATION WITH TEAM MEMBERS ACROSS THE NATION WILL ALSO LEAD TO NEW AND EXCITING TECHNICAL INNOVATIONS."

Hao Zhang
Professor of Biomedical Engineering

FUNDING COULD MAKE WHOLE-EYE TRANSPLANTS A REALITY

A multi-institutional team of researchers, including two from Northwestern Engineering, has been awarded up to $56 million from the Advanced Research Projects Agency for Health (ARPA-H) to help make vision-restoring, whole-eye transplants a reality. The funding will support a six-year effort to develop and test Viability, Imaging, Surgical, Immuno-modulation, Ocular preservation, and Neuroregeneration (VISION) strategies for whole-eye transplant.

The VISION team includes 40 scientists, medical doctors, and industry experts from across the United States. Team members will simultaneously advance and create cutting-edge medical devices, AI integrations, new surgical techniques, generative medicine breakthroughs, and transplant rejection mitigations.

McCormick School of Engineering professors Hao Zhang and Cheng Sun will help design, develop, and test a new generation of visible-light optical coherence tomography (vis-OCT), a functional imaging technology conceived at Northwestern that provides new capabilities for anatomical and functional imaging of the eye. With vis-OCT, researchers will analyze eyeballs from potential organ donors to determine whether they are suitable for harvesting.

The Northwestern team also will support imaging needs to evaluate eyeballs before transplant surgery and in fundamental investigations in animal models.

VISION is part of ARPA-H's Transplantation of Human Eye Allografts (THEA), a program that seeks to revolutionize the reconnection of nerves to the brain and develop breakthroughs in transplantation, preservation, and neuroscience to restore sight to people who are blind.

Eye transplants aren't new. Annually, more than 70,000 people in the United States donate their eyes after they die, allowing for life-improving and vision-saving transplants of the cornea, the clear, outermost layer of the eye. But those transplants don't address the most common causes of irreversible vision loss in the world: retinal neurodegeneration caused by diseases such as glaucoma, macular degeneration, and diabetic retinopathy.

THEA could fill in that gap. To do so, researchers will face the enormous challenge of determining how to regenerate a functional optic nerve, which connects the eye to the brain.

Engineering Students Named to Chicago Inno Under 25 List

This year's *Chicago Inno* Under 25 list recognized Northwestern Engineering undergraduates Trevor Abbott and Victoria Israel for their entrepreneurial achievements.

Abbott and Israel are revolutionizing data collection in healthcare with their startup HaptE. Both third-year students in mechanical engineering, they've developed innovative low-cost data-sensing gloves that track hand motions and grip strength for physical therapy applications. While HaptE has focused initially on improving patient outcomes in physical therapy, the technology has broader applications in manufacturing, logistics, and robotics. The startup has already secured pilot agreements with leading physicians. The two previously took second place in The Garage's Jumpstart pre-accelerator program.

SANJAY SOOD SHARES LEADERSHIP LESSONS WITH GRADUATES

Speaking at the 2024 PhD Hooding and Master's Degree Recognition Ceremony in December, Sanjay Sood ('02, PhD '07) recalled how he was encouraged at Northwestern to communicate his innovations in an accessible and engaging way.

"When people can relate to and understand the problem and solution, you inevitably get more support, excitement, and collaboration from those around you," said Sood, senior vice president and chief technology officer at CDW. Advising graduates to embrace a growth mindset, he added, "That is, always looking at challenges, change, and the unknown to improve yourself and your skills."

LAB NOTES

Hartmann cautions people not to fret about the invisible wildlife living within their bathrooms.

"WE WANT TO LOOK AT ALL THE FUNCTIONS THESE VIRUSES MIGHT HAVE AND FIGURE OUT HOW WE CAN USE THEM."

Erica Hartmann
Associate Professor of Civil and Environmental Engineering

These viruses don't target people; they target bacteria. This makes them potentially useful in treating antibiotic-resistant infections.

Viruses Are Teeming on Your Toothbrush, Showerhead

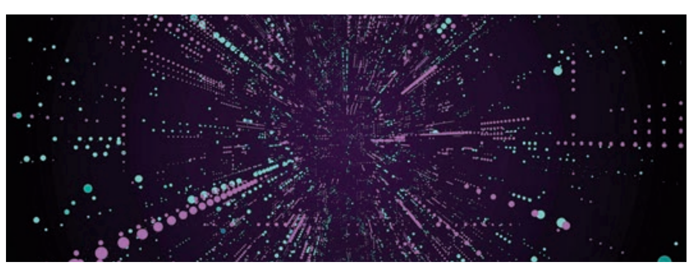
Step aside, tropical rainforests and coral reefs. The latest hotspot of awe-inspiring biodiversity lies no further than one's bathroom.

In a Northwestern Engineering-led study, microbiologists found that typical showerheads and toothbrushes teem with an extremely diverse array of viruses—most never seen before.

Ominous as that may sound, there is good news. These viruses don't target people. They target bacteria.

The microorganisms collected in the study are bacteriophages or "phages," a type of virus that infects and replicates inside bacteria. Although researchers know little about them, phages have recently garnered attention for their potential in treating antibiotic-resistant bacterial infections. Their abundance offers a treasure trove of material for exploring such applications.

"The number of viruses that we found is absolutely wild," says Professor Erica Hartmann, who led the study. She cautions people not to fret about the invisible wildlife living nearby. "We found many viruses that we know very little about and many others that we have never seen before. It's amazing how much untapped biodiversity is all around us. And you don't even have to go far to find it; it's right under our noses."



FIRST DEMONSTRATION OF QUANTUM TELEPORTATION OVER BUSY INTERNET CABLES

Northwestern engineers are the first to successfully demonstrate quantum teleportation over a fiberoptic cable already carrying internet traffic.

Quantum teleportation enables a new, ultrafast, secure way to share information between distant network users, wherein direct transmission is not necessary. The discovery introduces the new possibility of combining quantum communication with existing internet cables, greatly simplifying the infrastructure required for advanced sensing technologies or quantum computing.

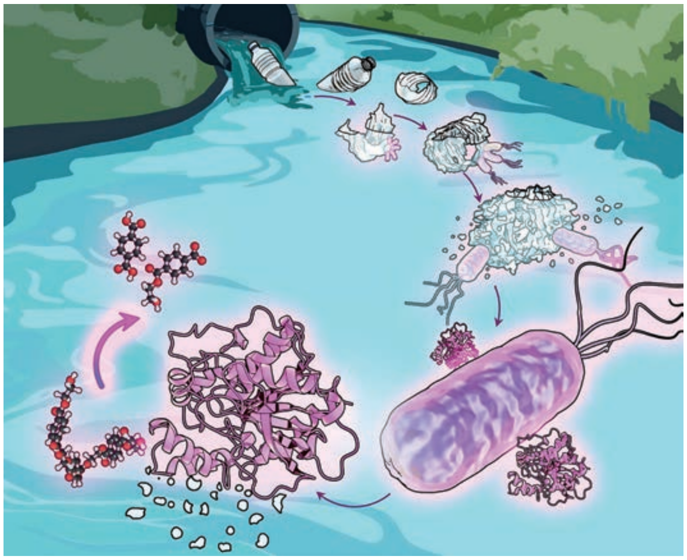
"This is incredibly exciting because nobody thought it was possible," says Professor Prem Kumar, who led the study. "Our work shows a path toward next-generation quantum and classical networks sharing a unified fiberoptic infrastructure."

Farewell Frost!

Someday, people might finally say good-bye to defrosting the freezer or scraping frost off slippery surfaces. Researchers led by Professor Kyoo-Chul Kenneth Park developed a new strategy that prevents frost formation before it begins.

They discovered that tweaking the texture of any surface and adding a thin layer of graphene oxide completely prohibits frost from forming on surfaces for one week or potentially longer—1,000 times longer than current, state-of-the-art anti-frosting surfaces.

As a bonus, the new scalable surface design also resists cracking, scratching, and contamination. By incorporating the textured surface into infrastructure, the researchers imagine companies and government agencies could save billions of dollars yearly in averted maintenance costs and energy inefficiencies.

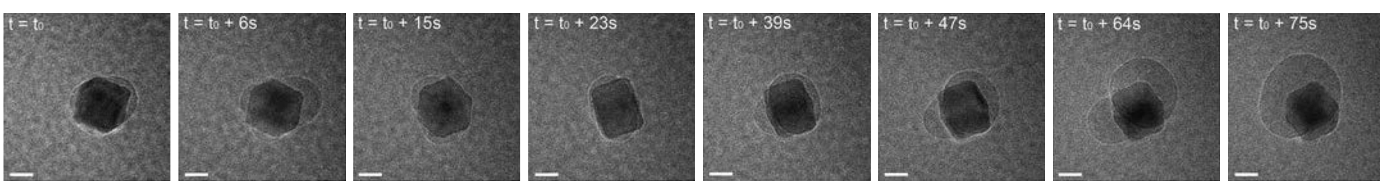


Wastewater Bacteria Can Break Down Plastic for Food

Scientists have known that a common family of environmental bacteria, *Comamonadaceae*, grow on plastic litter throughout urban rivers and wastewater systems. What these *Comamonas* bacteria are doing has remained a mystery.

Researchers led by Professor Ludmilla Aristilde discovered how cells of *Comamonas* bacteria break down plastic for food. First, they chew the plastic into small pieces, called nanoplastics. Then, the bacteria secrete a specialized enzyme that breaks down the plastic even further and use a ring of carbon atoms from the plastic as a food source. The researchers' discovery opens possibilities for developing bacteria-based engineering solutions to help clean up difficult-to-remove plastic waste, which pollutes drinking water and harms wildlife.

20 Students who attended the three-day hls4ml Summer School workshop	**15,000** Number of downloads of Silhouette, software developed by Professor Luís Amaral that analyzes images of gene expression in fruit flies	**40** Companies at the 2024 Fall Tech Career Fair



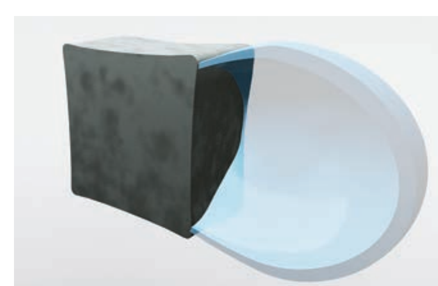
WATCHING WATER FORM OUT OF THIN AIR

For the first time ever, researchers watched—in real time at molecular scale—hydrogen and oxygen atoms merge to form tiny, nanosized bubbles of water. The reaction occurred as part of a Northwestern study during which scientists sought to understand how palladium, a rare metallic element, catalyzes the gaseous reaction to generate water. By witnessing the event at the nanoscale, the Northwestern team unraveled how the process occurs and uncovered strategies to accelerate it.

Because the reaction does not require extreme conditions, the researchers say it could be harnessed as a practical solution for rapidly generating water in arid environments, including on other planets.

"By directly visualizing nanoscale water generation, we were able to identify the optimal conditions for rapid water generation under ambient conditions," says Professor Vinayak Dravid, senior author of the study. "These findings have significant implications for practical applications, such as enabling rapid water generation in deep space environments using gases and metal catalysts, without requiring reaction conditions."

Viewing this process with atomic precision was impossible until the team unveiled a novel method to analyze gas molecules in real time. Now the team imagines that in the future, others can prepare hydrogen-filled palladium before traveling into space. Then, to generate water for drinking or for growing plants, travelers will only need to add oxygen. Although the study focused on bubble generation at nanoscale, larger sheets of palladium would generate much larger quantities of water.



- The process could be harnessed as a practical solution for rapidly generating water in arid environments, including on other planets.
- Researchers witnessed as it happened the molecular-scale hydrogen and oxygen atoms merging to form tiny, nanosized bubbles of water.
- Viewing this process with atomic precision was impossible until the team unveiled a novel method to analyze gas molecules in real time.

ANALYSIS REVEALS CHALLENGES TO INCREASING WATER RECOVERY FROM DESALINATION

While climate change is making water scarcer, desalination technology could enable converting seawater into freshwater. But desalination also adds the challenges of environmental impact, cost, and accessibility.

Zero liquid discharge (ZLD) technology aims to increase water recovery from desalination by squeezing more water out of desalination brine. ZLD can help reduce water scarcity and waste from desalination plants, but it comes at increased costs and potentially increased environmental effects. The pressure needed to push water through membranes requires a great deal of energy, a considerable obstacle to desalination and ZLD.

Using a novel optimization model for analysis, researchers led by Professor Jennifer Dunn concluded that while incorporating ZLD into desalination plants is a valuable way to fight future water scarcity, the process poses notable trade-offs when it comes to energy use and disposal of water containing salt.

“Desalination is crucial in certain regions, but it can’t be the only answer to water scarcity,” Dunn says. “To make real progress, we need to look at it as one piece of a broader, more sustainable water management strategy that’s adapted to the unique needs and constraints of each area.”

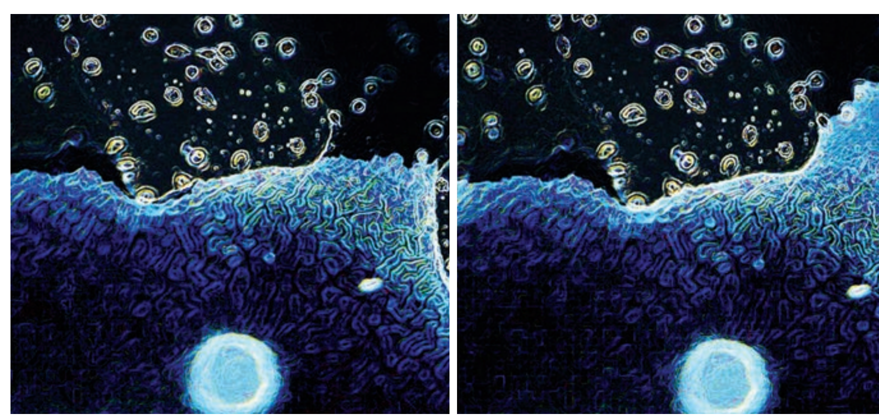
WHY PETTING YOUR CAT LEADS TO STATIC ELECTRICITY

Anyone who has ever petted a cat or shuffled their feet across the carpet knows that rubbing objects together generates static electricity. But an explanation for this phenomenon has eluded researchers for more than two millennia.

Northwestern Engineering scientists finally uncovered the mechanics at play.

When an object slides, the front and back parts of that object experience different forces, researchers found. The difference in forces causes different electrical charges to build up on the front and back parts of the object. That difference in electrical charges creates a current, leading to a light zap.

“For the first time, we are able to explain a mystery that nobody could before: why rubbing matters,” says Professor Laurence Marks, who led the study. “People have tried, but they could not explain experimental results without making assumptions that were not justified or justifiable. We now can, and the answer is surprisingly simple. Just having different deformations—and therefore different charges—at the front and back of something sliding leads to current.”



Novel “Scaffolding” Biomaterial Improves Bladder Regeneration and Function

Bladder tissue regeneration or augmentation is used to address impaired bladder control and function resulting from neurogenerative diseases or cancer.

Historically, tissue engineering has relied on cell-seeded scaffolds, a procedure that involves taking tissue cells from a biopsy, growing the cells on a scaffold-like material, and then implanting that scaffold into a specific organ. Still, there remains a need for cell-free biomaterials that are more robust and cost-efficient to manufacture.

Using an advanced technique called plasticizing functionalization, a team of Northwestern scientists led by Professor Guillermo Ameer developed an electroactive scaffolding material that improves bladder tissue regeneration and organ function better than current techniques. The biomaterial could improve outcomes in patients with impaired bladder function and reduce the need for additional high-risk surgical procedures.

FUTURE-PROOFING US EMBASSIES AND CONSULATES

US embassy and consulate structures are designed to withstand a diverse set of dire yet plausible threats. These secure buildings are blast-proof, bulletproof, fireproof, natural disaster-proof, and even gasproof.

Northwestern Engineering experts want to make them climate-proof. In partnership with the US Department of State Bureau of Overseas Buildings Operations and Chicago-based architecture firm Krueck Sexton Partners, Northwestern civil and environmental engineers spent five years reimagining the United States' diplomatic locations—specifically, the approximately 175 embassies and 90 consulates—around the globe.

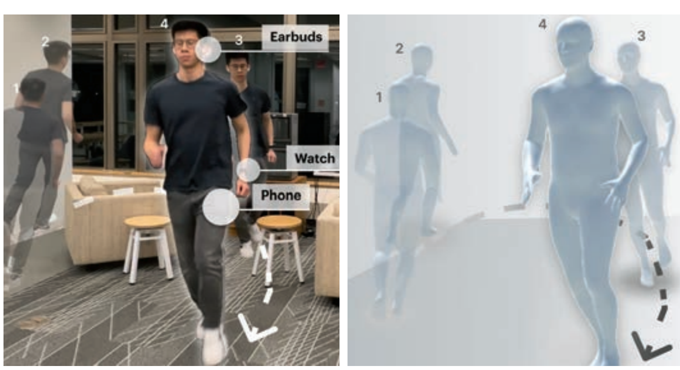
The final designs of this project ensure these buildings remain safe, secure, and functional while increasing their resilience to climate change, technological advancements, population shifts, urbanization, and resource scarcity.

The project's roadmap, "Embassy 2050," was completed last summer and co-led by Professor Kimberly Gray alongside 10 other McCormick School of Engineering faculty. The State Department is determining how to implement various aspects of the project into its six-year capital plan.

The Human Genome Operates Like a Dynamic Computer

A study from Northwestern Engineering's Center for Physical Genomics and Engineering revealed that the human genome operates less like a static instruction manual and more like a sophisticated computer that integrates signals to form 3D structures essential for cell function. As with a computer, scientists may soon be able to "reprogram" cellular memories to create radically new strategies for improving human health, combatting disease, and increasing longevity.

Using advanced imaging and analysis techniques developed at Northwestern, the researchers showed how these genome structures can store and create transcriptional memories, allowing cells to perform their roles effectively across an entire lifetime.



New Mobile App Captures Full-Body Motion in Real Time

Northwestern engineers, led by Professor Karan Ahuja, developed a new system for full-body motion capture that unlocks new possibilities in gaming and fitness—and all it requires is a simple mobile device.

Called MobilePoser, the new system leverages sensors already embedded in consumer mobile devices, including smartphones, smartwatches, and wireless earbuds. Using a combination of sensor data, machine learning, and physics, MobilePoser accurately tracks a person's full-body pose and translation in space in real time.

NEW APPROACH TO PREDICTING PNEUMONIA OUTCOMES ACCURATELY

Pneumonia, a leading cause of death globally, is inherently difficult to treat because it can present and be acquired in diverse ways. When patients being treated for pneumonia look vastly different and have opposing outcomes, physicians can struggle to determine the most effective treatments and predict prognoses accurately.

By applying a sophisticated machine-learning approach to analyzing electronic health records of pneumonia patients, Northwestern Engineering researchers uncovered five distinct clinical states, three of which are strongly associated with disease outcomes and two that can help physicians determine the disease's cause. One of the states was associated with a 7.5 percent chance of dying within 24 hours.

The five states integrate many types of data (including body temperature, breathing rate, glucose level, and oxygenation level) to establish relationships between different measures.

Led by Professor Luís Amaral, the researchers believe there is potential for clinicians to use the approach to make better informed treatment decisions for critically ill patients and to apply it more broadly to treating other medical conditions. Next, the team is applying the same techniques to investigate sepsis.


Guillermo Ameer


Hani Mahmassani


Igor Efimov


Horacio Espinosa


Julia Gaudio


Niall Mangan


Ted Sargent


Zdeněk Bažant


Linsey Seitz


Mahdi Hosseini


Cécile Chazot


Xiao Wang

Faculty Awards

Guillermo Ameer Receives Percy L. Julian Award
The most prestigious award given by the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers recognizes significant contributions in pure and/or applied research in science or engineering.

Horacio Espinosa and Ted Sargent Named to National Academy of Inventors
They are among 170 new fellows in the 2024 class who attained the highest professional distinction awarded solely to inventors.

Mahdi Hosseini Receives DARPA Young Faculty Award
With the award from the Defense Advanced Research Projects Agency, Hosseini and his group aim to pioneer a fundamentally new technique in controlling and reading information from sensors.

Hani Mahmassani Named 2024 INFORMS Fellow
In earning one of the highest honors in the operations research profession from the Institute for Operations Research and the Management Sciences, Mahmassani was recognized for contributions to transportation science and leadership in the field.

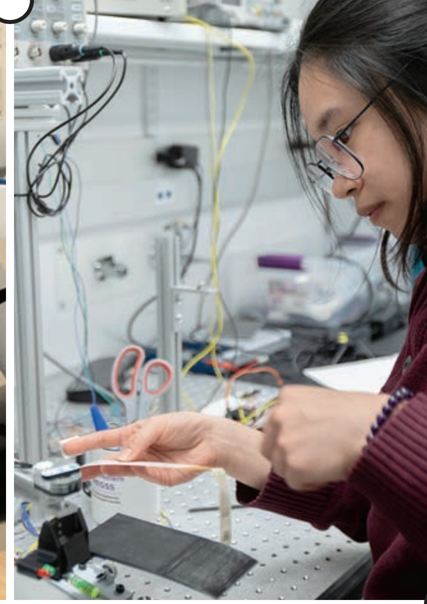
Julia Gaudio Receives Prestigious NSF CAREER Award
The award, the US National Science Foundation's most prestigious honor for junior faculty members, will support research into inference and reconstruction problems on networks.

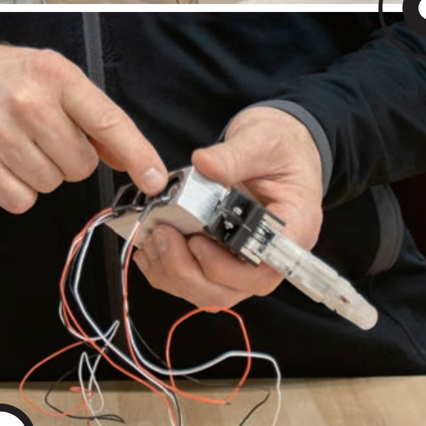
Zdeněk Bažant Elected a Royal Society of Canada Fellow
An expert in the mechanics of solids and structures, Bažant was one of 104 fellows elected to this year's class for outstanding scholarly achievements.

Cécile Chazot Receives Army Research Laboratory Early Career Program Award
One of the most prestigious honors bestowed by the US Army, the award will help Chazot develop liquid crystalline conductive and structurally colored fibers that can change appearance when exposed to an electrical current.

Igor Efimov Receives Ralph Lazzara Lectureship Award
The award, given by the Heart Rhythm Society, honors individuals who have made a significant and unique contribution in clinical electrophysiology.

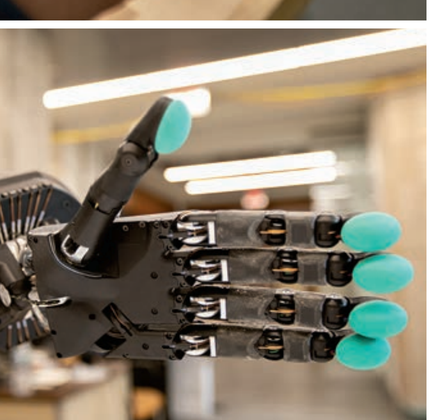
Niall Mangan, Linsey Seitz, and Xiao Wang Awarded Sloan Research Fellowships
Gifted by the Alfred P. Sloan Foundation, the honor highlights the creativity, innovation, and research accomplishments of early-career researchers.





LENDING A HAND

A new Northwestern Engineering-led research center—the latest milestone in the school's long history of robotics leadership—is on a mission to create dexterous robot hands that could transform manufacturing, caregiving, and more.



The human hand is amazingly complex. With 34 muscles, more than 30 tendons, and 27 bones, hands can grasp objects, express emotion, create works of art, and accomplish many of the tasks that drive economic progress and help care for those in need.

Imagine the possibilities if we had more of them.

Boston Consulting Group projects that by 2030, the US GDP will take a $290 billion annual hit because of worker shortages in health and social services. Similarly, Deloitte anticipates 2.1 million unfilled US manufacturing jobs by 2030, which could lead to $1 trillion in economic losses.

Fortunately, help is on the way. Northwestern engineers in the new US National Science Foundation Human AugmentatioN via Dexterity Engineering Research Center (HAND ERC) are working to mitigate this impending labor shortfall by developing dexterous, intelligent robot hands with the ability to assist humans with manufacturing, caregiving, handling precious or dangerous materials, and more.

"We're working toward the day, probably a decade down the road, when a small manufacturing firm can hire people who know its business, are not programmers, but can buy a manufacturing robot and put it to use very quickly and quite differently from the way robots are used today," says J. Edward Colgate, Walter P. Murphy Professor of Mechanical Engineering at Northwestern Engineering and director of HAND ERC.

LEADING A TRANSFORMATIVE ERA

Funded with $26 million over five years from the NSF—with the ability to renew for another $26 million for an additional five years—HAND ERC is the first Northwestern-led NSF engineering research center. Its core partners include Carnegie Mellon University, Florida A&M University, Texas A&M University, and the Massachusetts Institute of Technology, with additional faculty support from Syracuse University and the University of Wisconsin-Madison.

Leveraging state-of-the-art research testbeds from around the country, the multi-institutional collaboration will advance research in dexterity (versatile robotic manipulation that rivals the human hand) and augmentation (new interfaces enabled by AI to democratize access to robotics) to support a future that accelerates worker and company productivity alike.

"We're entering a transformative era where robotics will not only enhance productivity but also will fundamentally change how humans and machines collaborate," says Northwestern Engineering Dean Christopher Schuh. "HAND ERC represents a bold step toward that future, positioning Northwestern Engineering at the forefront of dexterous robotics research and innovation."

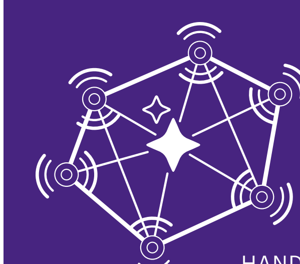
Photos by Sally Ryan

A HISTORY OF ROBOTICS INNOVATION AT NORTHWESTERN

HAND ERC is the latest chapter in the story of robotics innovation at Northwestern Engineering. It began in the 1950s, when Northwestern Engineering professor Dick Hartenberg and PhD student Jacques Denavit created a way to represent mathematically how mechanisms move, developing what became the widely used Denavit–Hartenberg parameters for the kinematics of robots. More recently, in 2019, the school launched the Center for Robotics and Biosystems, a multidisciplinary research center at the intersection of robotic and biological systems.

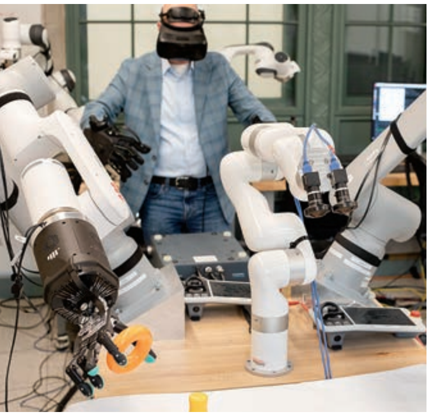
Colgate's pioneering work in the field began in the early 1990s when he and fellow mechanical engineering professor Michael Peshkin collaborated with General Motors to develop a new type of robot that could augment worker performance on factory floors safely. Their invention of collaborative robots, known as "cobots," allowed human workers to operate in concert with machines to manipulate heavy car parts, preserving valuable worker independence and empowerment while the robots performed the heavy lifting.

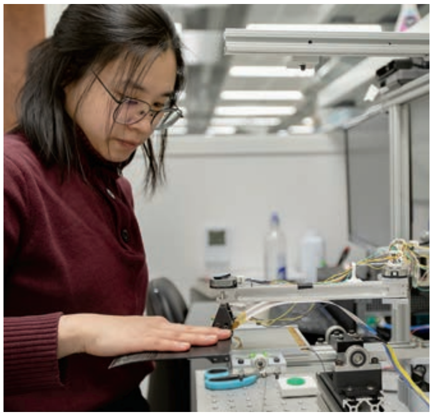
Cobots transformed the robotics field, ushering in a new paradigm of how humans could work collaboratively with machines. "Cobots were tools for helping people do their jobs better, faster, and more safely, whether through direct assistance, like what you experience in power steering, or completely taking over a task, like a car's cruise control," Colgate says. "The same motivation that pushed us to develop cobots drives us today with HAND ERC. How can we leverage our understanding of robotics to improve people's lives?"



Embodied AI

HAND ERC's research advances Northwestern Engineering's leadership in embodied AI. A strategic priority for the McCormick School of Engineering, such research leverages the school's strengths in robotics, AI and machine learning, and sensor networks to maximize AI's impact in the physical world. Embodied AI enables the development of intelligent mechanical systems for use in complex networks such as the power grid, autonomous vehicles, smart factories, and, yes, dexterous, intelligent robot hands.





left to right Professor J. Edward Colgate operates the Dexterity Nexus teleoperation testbed for dexterous robotic manipulation.

PhD student Sylvia Tan tests PixeLite, a haptic device for fingerpad tactile feedback. This technology could be integrated into robotic systems to enhance human-robot interaction by providing more realistic and nuanced touch sensations.

A three-degree-of-freedom robotic finger, capable of performing the same motions as a human finger. These fingers can be combined to form a lightweight, human-scale robot hand.

Photos by Sally Ryan

A VISION FOR THE FUTURE

Shifting attention from the large-format work of cobots, HAND ERC will focus on the fine motor skills of hands with several interwoven goals for revolutionizing robotics:

MAKE IT VERSATILE:
Advancing robot hand hardware

At the core of HAND ERC's work will be expanding robot dexterity capabilities. Using advances in tactile sensing, soft actuators, and improved tendons, center researchers will design robots that can manipulate objects—assemble, twist, tear, and stack—instead of the robot simply moving from place to place.

Manipulation and movement might seem like similar challenges, but they're worlds apart in complexity. Legged locomotion is relatively straightforward: pick up a foot, put it down; keep moving forward, don't fall. Robotic hand movements are much more intricate. Each finger has multiple degrees of freedom, and when handling objects, every touchpoint changes the dynamics of movement.

Add tools or multiple objects into the mix and the task becomes exponentially harder. "The challenge is developing robot hands that can perform everything from fine in-hand manipulation, such as tying shoelaces or using chopsticks, to power grasps that can open a sealed jar," says Kevin Lynch, professor of mechanical engineering and HAND ERC research director.

MAKE IT SMART:
Augmenting robot learning with embodied AI

Equipping robots with the mechanical and sensing capabilities to manipulate dexterously, however, is only one of the challenges HAND ERC researchers are working to overcome. Another is providing robots with human-like reflexes and control policies that map sensor feedback to hand motor controls. Although AI and machine learning have supported intelligent control of relatively simple robots, applying machine learning systems to control policies for robot hands is far more challenging due to the robot's large number of actuators, joints, and tactile sensing channels. The amount of data needed to learn these control policies is significant, and it does not currently exist.

To overcome this challenge, HAND ERC researchers are developing a powerful system that allows an operator to intuitively teleoperate hand-equipped robot arms via a virtual reality headset, allowing the user to see what the robot sees, and haptic gloves, which let the user feel what the hands' tactile sensors feel. Data collected during teleoperated dexterous tasks can then be used to train the robot's autonomous skills. In addition, the experimental data will be augmented by large-scale synthetic data from simulation.

These methods will help robots become better prepared to seamlessly integrate with human workers in a variety of settings, from manufacturing facilities to hospitals to homes. They will provide even more effective support the longer they operate in those environments and collect data.

"Easy-to-use AI-enabled robot hands will become facilitators of creativity," Lynch says. "They will allow people to do things that we would not have imagined."

MAKE IT ACCESSIBLE:
Moving the technology out into society

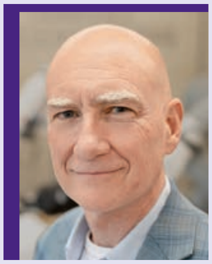
Fifty years ago, owning a computer was only practical for the largest and richest companies. Today, computers are more affordable and used by nearly everyone.

Through HAND ERC, Colgate envisions a similar future for robotic hands—inexpensive, easy to operate, robust, durable, and mass-manufacturable. "We have economists on our team," Colgate says. "What we've learned is that when you drive productivity, you drive opportunity and wages and make things better for the economy and for people. That is the big vision."

Colgate is confident in his collaborators. He is passionate about translating work from the lab to the marketplace and sees HAND ERC as an opportunity to make a major impact on countless fields while creating new jobs fit for the 21st century. "Translation is vitally important in robotics," Colgate says. "We've worked hard to build a strong robotics community at Northwestern, one that is interested in how we can have the greatest impact and add value to the world."

ASSEMBLING THE NORTHWESTERN TEAM

To achieve HAND ERC's mission to democratize access to robotic manipulation, the center has convened leading robotics minds from five core universities across the United States. Eight faculty from Northwestern Engineering will play pivotal roles advancing research and industry collaboration.



J. EDWARD COLGATE

Director
Walter P. Murphy Professor of Mechanical Engineering

A pioneer in haptics interfaces and human-machine interaction, Colgate supervises the center and co-leads the Hands research thrust.

JIAN CAO

Manufacturing Processes
Cardiss Collins Professor of Mechanical Engineering

Cao applies her expertise in manufacturing processes and systems to develop new paths to robust, low-cost robots.

KEVIN LYNCH

Research Director
Professor of Mechanical Engineering

An expert in robotic manipulation and physical human-robot collaboration, Lynch oversees HAND ERC's entire research portfolio.

TODD MURPHEY

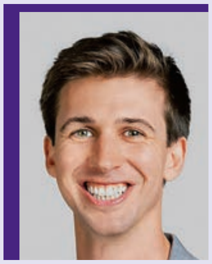
Intelligent Dexterity Co-Lead
Professor of Mechanical Engineering

Murphey, an expert in embodied intelligence, will develop efficient machine learning techniques and address questions of cybersecurity.

BRENNA ARGALL

Intelligent Dexterity Thrust Leader
Professor of Computer Science, Mechanical Engineering, and Physical Medicine and Rehabilitation

Argall, who studies how to advance human autonomy through robotics autonomy, leads HAND ERC's Intelligent Dexterity research thrust.



RYAN TRUBY

Advanced Actuation
June and Donald Brewer Junior Professor of Mechanical Engineering and Materials Science and Engineering

Truby studies machine intelligence and materials design to create new actuators for future dexterous robots.

LIZ GERBER

Human-Centered Design Lead
Professor of Mechanical Engineering

An expert in human-computer interaction and design, Gerber examines how robots can be optimized to promote a collaborative and sustainable society.

MATTHEW ELWIN

System Integration
Associate Professor of Instruction of Mechanical Engineering

Elwin will play a central role in HAND ERC's system integration and testbeds, as well as education and outreach.

"We're working toward the day, probably a decade down the road, when a small manufacturing firm can hire people who know its business, are not programmers, but can buy a manufacturing robot and put it to use very quickly and quite differently from the way robots are used today."

J. Edward Colgate Director, Walter P. Murphy Professor of Mechanical Engineering

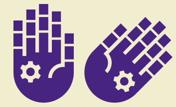
THE RESEARCH PATH TO ROBOTIC HANDS

While robots already play an important role in manufacturing and can improve workers' job quality, Northwestern Engineering researchers at HAND ERC believe the full potential of current models has been limited. Developing robotic hands as versatile and dexterous as human hands will enable robots to expand human capabilities and boost industry competitiveness.

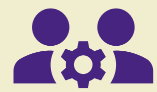
> **"HAND ERC's fundamental research will lead to robots with dexterous and versatile hands, manual skills, and intuitive interfaces that anyone can learn to use."**
>
> **J. Edward Colgate** Director, Walter P. Murphy Professor of Mechanical Engineering

"Rapid advances in AI have created an incredible opportunity to make robot manipulators accessible to small and medium enterprises, people with motor impairments, and many others who might benefit," Colgate says. "A huge challenge, however, is what we put at the end of the robot's arm. Today's two-jaw grippers are far too limited. HAND ERC's fundamental research will lead to robots with dexterous and versatile hands, manual skills, and intuitive interfaces that anyone can learn to use."

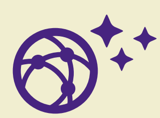
To achieve its goal, HAND ERC will focus on **three research thrusts**.



HANDS Led by Carnegie Mellon University's Carmel Majidi, this research thrust will develop robotic hands that are soft yet durable enough to survive the harshest conditions. The robotic hands will feature tactile sensing, advanced actuators, and improved tendons to far exceed the state of the art.

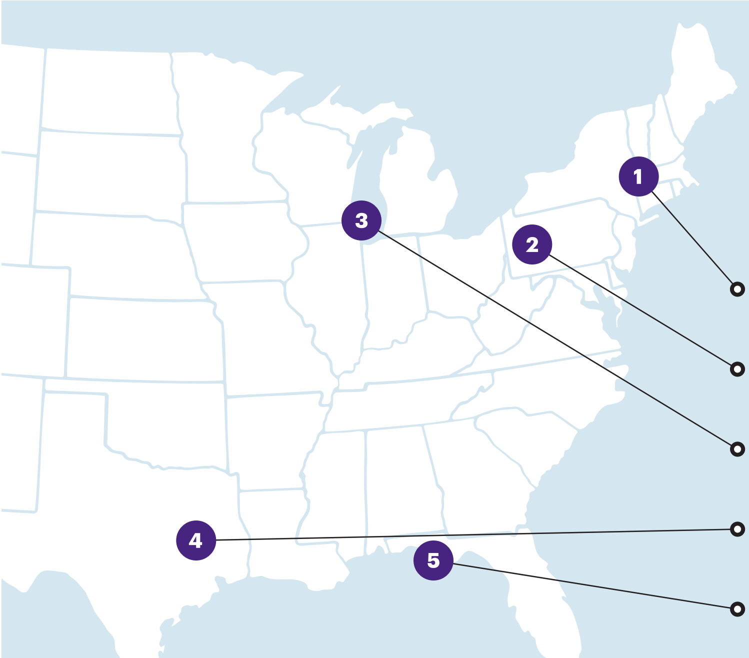


HUMAN INTERFACE This thrust, led by the Massachusetts Institute of Technology's Julie Shah, is focused on making advanced robot hands easy to use by nonspecialists. More than just dexterity (what robot hands are capable of), researchers will explore human augmentation (what humans can do with robot hands). Projects include multimodal human interfaces for controlling robot hands and methods for low-code programming. This thrust will also study the social, legal, and industrial impacts of dexterous robots.



INTELLIGENT DEXTERITY Led by Northwestern Engineering's Brenna Argall, this thrust will develop AI-powered autonomous skills for advanced robot hands based on both teleoperator training data and simulated data. This library of skills will grow over time as the robot hands are applied to a variety of tasks within the center's application testbeds.

TESTBEDS



To evaluate its research advances on high-impact applications, such as manufacturing, food preparation, and caregiving, HAND ERC will maintain five testbeds throughout its partner ecosystem.

Testbed 1: High-Mix Manufacturing
Institution: Berkshire Innovation Center

Testbed 2: Assembly/Disassembly
Institution: Manufacturing Futures Institute

Testbed 3: Assistance and Caregiving
Institution: Shirley Ryan AbilityLab

Testbed 4: High-Consequence Material Handling
Institution: Texas A&M University

Testbed 5: Dexterity Education
Institution: Florida A&M University

A LEGACY OF LEADERSHIP

Since the 1950s, when Northwestern Engineering professor Dick Hartenberg and PhD student Jacques Denavit created the Denavit–Hartenberg parameters for the kinematics of robots, Northwestern Engineering has cultivated leaders in the robotics field. As the discipline has grown and evolved, so has robotics work at Northwestern.

Robotics research and education milestones at the University over the last 30 years include:

1996

Through their Laboratory for Intelligent Mechanical Systems (LIMS), Professors J. Edward Colgate and Michael Peshkin create the **first collaborative robots**, or cobots, to assist General Motors assembly line workers on factory floors.

2005

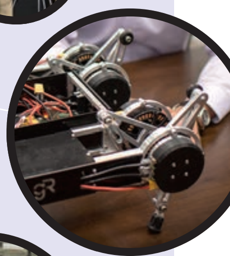
Northwestern completes construction of the **Ford Motor Company Engineering Design Center**, providing state-of-the-art lab space for undergraduate education in robotics and mechatronics.

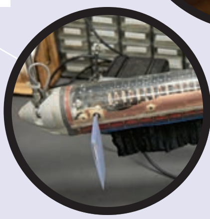
2014

Northwestern Engineering launches the **Master of Science in Robotics program**, a hands-on degree program designed to prepare students for the fast-paced challenges of the modern robotics industry.

2012

The Technological Institute's new Willens Wing opens, joining the labs of robotics researchers Malcolm MacIver, Mitra Hartmann, and Todd Murphey with that of Kevin Lynch, J. Edward Colgate, and Michael Peshkin. LIMS is retired, and the new combined lab space is named the **Neuroscience and Robotics Lab**, accounting for new research areas in neuromechanics and bio-inspired robotics research.





2019

Northwestern Engineering's Department of Mechanical Engineering launches a **concentration in robotics** that emphasizes hardware design, dynamics, human-robot interaction, sensing, and AI for robots. The school also introduces the **Robot Design Studio** course sequence, a capstone experience for undergraduate and master's students, where participants work in teams to design and build robust robotic systems.

Northwestern Engineering launches the **Center for Robotics and Biosystems** under the direction of Professor Kevin Lynch. The interdisciplinary center's 12,000-square-foot headquarters, located in the Technological Institute's AB Wing, features a robot zoo, a collaborative common space, and an atrium to test drones.

2023

Project Drive, a team led by Professor Brenna Argall, begins work to bring to market the first active-driving assistance system for power wheelchairs, increasing access to safe, independent wheelchair operation.

2024

A large multi-institutional collaboration led by Northwestern receives $26 million from the US National Science Foundation to launch the **Human AugmentatioN via Dexterity Engineering Research Center**, dedicated to revolutionizing the ability of robots to amplify human labor.

RISE OF THE COBOTS

Nearly 30 years before Northwestern Engineering was selected to lead HAND ERC, Professors Ed Colgate and Michael Peshkin revolutionized human-robot collaboration with their invention of “cobots.”

Supported by a grant from General Motors, Colgate and Peshkin were tasked with developing a new robotics system to function in concert with—not separately from—human employees working on GM’s automobile assembly lines.

To understand the challenge, the team observed and worked with GM’s assembly line workers as they guided bulky, awkward parts, such as dashboards or heating and cooling units, into cabs along a moving assembly line. They learned that coaxing parts into tight spaces at odd angles sometimes left workers feeling tired, even in pain.

Colgate and Peshkin designed a safe robot that could work closely with humans and make their work easier. These cobots used computer-controlled pathways to support and guide a payload into its desired location smoothly while remaining under the immediate physical control of the worker.

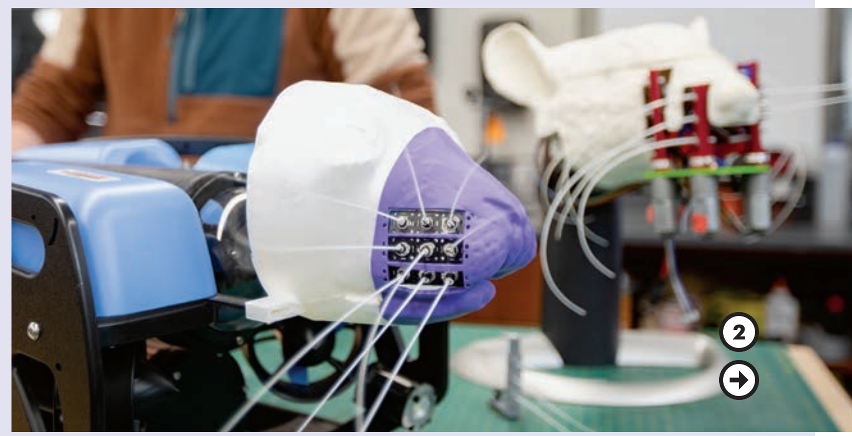
Colgate and Peshkin translated their invention into a company called Cobotics, which was eventually purchased by the Stanley Works. Today, the term cobot is used generically for all collaborative robots.

Northwestern remains a hub for cobot innovation today.

In 2022, researchers from the Center for Robotics and Biosystems unveiled mobile cobots, or “mocobots.” These mobile manipulators act as assistants for humans, collaborating with each other and supporting a payload at multiple points of contact, rendering heavy objects weightless and easily maneuverable. The technology could help usher in a new era of human-robot interaction in environments such as warehouses, construction zones, manufacturing plants, and even Mars.

“When Ed and I started at Northwestern, the primary goal of robotics research was autonomy—could robots do what people can do? We embarked into cobots looking instead for how robots and people could best work together, each bringing their own strengths.”

Michael Peshkin
Allen K. and Johnnie Cordell Breed Senior Professor in Design and Professor of Mechanical Engineering



1 Michael Peshkin (left) and Ed Colgate, inventors of cobots. Photo by Sally Ryan

2 Faculty in the Center for Robotics and Biosystems advance robotics research by studying how rats use their whiskers. Photo by Sally Ryan

3 Kevin Lynch directs three mocobots carrying a large payload. Photo by Matthew Allen

4 Through Project Drive, Brenna Argall (right) is using robotics autonomy to overcome barriers to independent wheelchair mobility. Photo by Shane Collins

ADVANCING COLLABORATIVE ROBOTICS THROUGH BIO-INSPIRED SCIENCE

Since its founding in 2019, the Center for Robotics and Biosystems (CRB) has had one mission: develop robotic systems that complement and augment human behavior, not replace it.

Directed by Professor Kevin Lynch, the interdisciplinary center brings together faculty from mechanical engineering, biomedical engineering, and computer science as well as Northwestern's Feinberg School of Medicine and the Shirley Ryan AbilityLab. Here, researchers are advancing the science and engineering of embodied AI; AI-supported sensors, actuators, and controllers are inspired by biological principles; and robotics and computational modeling come together to create breakthroughs in human and animal neuromechanics.

"We take pride in our interdisciplinary research, innovation, and collaboration," Lynch says. "By integrating advances in autonomy, human-machine interaction, and bio-integrated technologies, we're preparing the next generation of researchers and engineers to tackle the world's most pressing challenges."

The CRB emphasizes **five areas of robotic research**:

- **Bio-inspiration, neuromechanics, and neuroscience**
  Analyzing animal systems to better understand neuromechanics and to inspire new robot designs.
- **Human-machine systems**
  Advancing haptic interfaces, prosthetics, and human-robot co-adaptation to improve how humans and robots interact.
- **Swarm robotics and decentralized computation**
  Designing behavior laws for individual robots to yield a desired group behavior.
- **General autonomous robotics**
  Using sensory data, AI, machine learning, and motion planning and control to help robots make real-time decisions in changing environments.
- **Soft robotics**
  Advancing robot machine intelligence through the design of innovative new materials.

In addition to research, the center supports robotics education through specialized undergraduate and PhD degree concentrations, the Master of Science in Robotics program, and the NU Robotics Club student group.

"We take pride in our interdisciplinary research, innovation, and collaboration."

Kevin Lynch Professor of Mechanical Engineering

TRANSLATING ROBOTICS RESEARCH

Northwestern Engineering robotics researchers aren't content to keep their innovations as proofs of concept in their labs. They consider it part of their mission to help people—industrial workers, physical therapists, surgeons, consumers, and others—perform tasks and live better lives.

A few examples of faculty-founded startup companies and commercialization efforts based on robotics research at Northwestern include:

- **Tanvas**
  Research on surface haptics led to the development of the world's first commercial haptic touch screens, which use electroadhesion to allow a user to feel programmable textures on a smooth glass touch screen. This technology was first commercialized by Tanvas, a startup founded by Professors J. Edward Colgate and Michael Peshkin.
- **Kinea Design**
  Founded by Colgate and Peshkin, Kinea Design created KineAssist, a treadmill-like therapy system for gait and balance recovery to support physical therapists and their patients who are regaining the ability to walk. HDT Global acquired the company in 2011, while Shirley Ryan AbilityLab now owns KineAssist.
- **MAKO Surgical Corp.**
  Founded by Peshkin, MAKO Surgical Corp. (originally named Z-KAT) developed robotic arm assistance platforms used by orthopedic surgeons in partial knee and total hip arthroplasty procedures. The company was acquired by Stryker Corp. in 2013 for $1.65 billion.
- **Project Drive**
  Supported by the US National Science Foundation, Professor Brenna Argall is leading an interdisciplinary collaboration of academic, industry, and nonprofit members in using machine intelligence and robotics autonomy to bring to market the first active-driving assistance system for power wheelchairs, increasing access to safe, independent wheelchair operation.

BRIAN SANDALOW

NORTHWESTERN ENGINEERING RESEARCHERS ARE DEFINING THE FUTURE OF MEDICINE AND HEALTH THROUGH ELECTRONICS AND INNOVATIVE MATERIALS FOR APPLICATIONS WITHIN AND ON THE HUMAN BODY.

BIOHYBRID SYSTEMS FOR BETTER LIVING

A wearable sensor system that predicts fatigue at work. A tiny implant that delivers diabetes drugs on demand. A flexible patch that optimizes the sense of touch for the visually impaired.

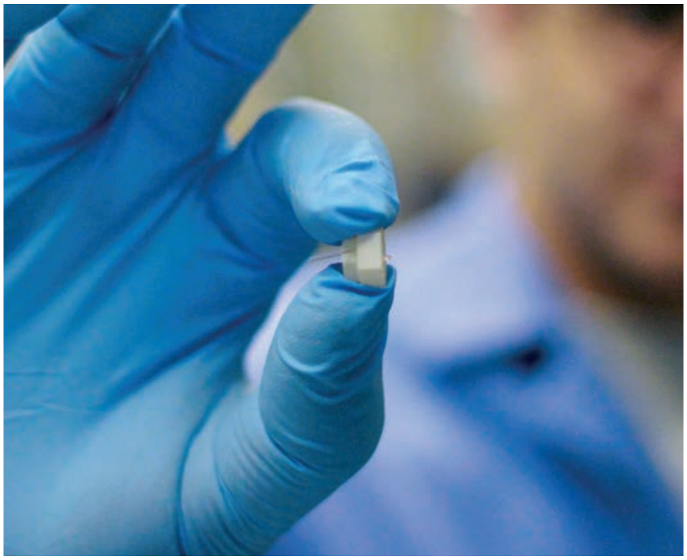
Through the work of Northwestern Engineering researchers, bioelectronics like these are becoming the future of medicine. These biohybrid systems use innovations in materials and mechanical structures to overcome the mismatch between hard, rigid electronic semiconductor devices and the soft, flexible tissue and organs within the human body.

The results are new platforms and capabilities that can be integrated on and within human tissue, opening up unprecedented clinical healthcare possibilities, including treating and monitoring disease, supporting work-based performance, and optimizing overall health and well-being.

IMPLANTABLE DEVICE TO MONITOR INFLAMMATION

"The device's design is analogous to a continuous glucose monitor that sits on your arm and measures levels right beneath your skin. This is a completely new capability—to watch inflammation in real time—with a huge number of applications that we are exploring."

SHANA O. KELLEY



LED BY

Shana O. Kelley
Neena B. Schwartz Professor of Chemistry and Biomedical Engineering

THE PROBLEM Although inflammation is inherent in many diseases, including cancer and heart disease, physicians currently cannot track inflammation in tissue in real time.

THE IDEA A small, implantable device that can monitor fluctuating levels of proteins within the body. Inspired by fruit being shaken off tree branches, the device comprises strands of DNA that stick to proteins, shake them off, and then grab more proteins. This enables the device to sample various proteins over time and measure changes in inflammatory markers in real time.

WHY IT MATTERS The work on this idea lays the foundation for managing and preventing acute and chronic conditions by tracking critical proteins such as cytokines in inflammation, protein biomarkers in heart failure, and many others. With continuous monitoring, physicians could fine-tune medications between visits, helping to alleviate or even prevent disease.

HAPTIC PATCH THAT STIMULATES SKIN FOR COMPLEX SENSATIONS

LED BY

John A. Rogers
Louis Simpson and Kimberly Querrey Professor of Materials Science and Engineering, Biomedical Engineering, and Neurological Surgery

Yonggang Huang
Jan and Marcia Achenbach Professorship in Mechanical Engineering

"THIS SORT OF 'SENSORY SUBSTITUTION' PROVIDES A PRIMITIVE, BUT FUNCTIONALLY MEANINGFUL, SENSE OF ONE'S SURROUNDINGS WITHOUT RELIANCE ON EYESIGHT—A CAPABILITY USEFUL FOR INDIVIDUALS WITH VISION IMPAIRMENTS." **JOHN ROGERS**

THE PROBLEM Existing haptic feedback technology, which creates the experience of touch through forces and vibrations, has limitations, especially for people with disabilities and those within virtual reality simulations.

THE IDEA A thin, flexible device that adheres to skin and delivers various complex sensations and more realistic, immersive sensory experiences. The device comprises a hexagonal array of 19 small magnetic actuators encapsulated within a thin, flexible silicone-mesh material. Each actuator can deliver different sensations, including pressure, vibration, and twisting. Using Bluetooth technology on a smartphone, the device receives data about a person's surroundings for translation into tactile feedback—substituting one sensation (like vision) for another (touch).

WHY IT MATTERS The device could help people with visual impairment "feel" their surroundings. The system can support a basic version of vision in the form of haptic patterns delivered to the surface of the skin based on data collected using the 3D imaging function (LiDAR) available on smartphones.

IMPLANT TO DELIVER THERAPY FOR OBESITY, TYPE 2 DIABETES

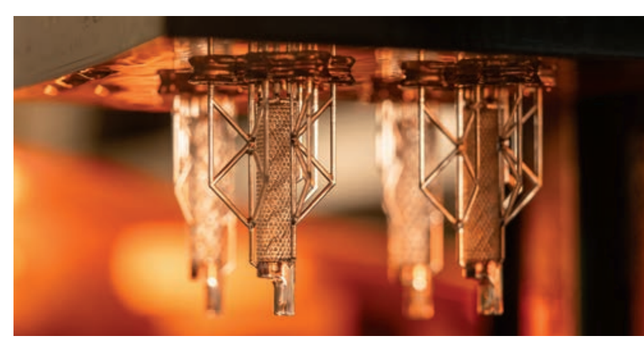
LED BY

Jonathan Rivnay
Professor of Biomedical Engineering and Materials Science and Engineering

Josh Leonard
Professor of Chemical and Biological Engineering

THE PROBLEM More than 40 percent of US adults have obesity, and more than 35 million Americans have type 2 diabetes. Researchers are seeking novel ways to create and deliver medications to treat these widespread conditions.

THE IDEA A low-cost bioelectronic implant to treat obesity and type 2 diabetes. Rivnay and Leonard are developing "Rx On-site Generation Using Electronics" (ROGUE), an implantable device that will deliver a biological therapy on demand. Measuring only a few millimeters in diameter, the implant will house living engineered cells that synthesize and deliver therapy when needed.



"THIS WORK BUILDS ON THE BIOHYBRID WORK SEEDED AT NORTHWESTERN, WHERE WE ARE MAKING REGULATED THERAPIES BASED ON ENGINEERED CELL FACTORIES THAT CAN BE CONTROLLED AND MAINTAINED BY A BIOELECTRONIC DEVICE." **JONATHAN RIVNAY**

WHY IT MATTERS The minimally invasive living device can be implanted under the skin to deliver personalized and regulated therapies, ultimately eliminating the need for daily or weekly injections, trips to the pharmacy, and careful storage of expensive medications.

WEARABLE FATIGUE-PREDICTION SENSOR SYSTEM

LED BY

Ping Guo

Associate Professor of Mechanical Engineering

Qi Zhu

Professor of Electrical and Computer Engineering

THE PROBLEM A 2018 National Safety Council report noted that 63 percent of manufacturing workers report feeling tired at work, which increases the risk of accidents and injuries and decreases overall performance.

THE IDEA A wearable, multimodal sensor system that leverages machine learning to enable near-real-time fatigue prediction and reporting on the factory floor. The system uses soft, flexible sensors to continuously monitor locomotive skills and vital signs, including heart rate and skin temperature. The sensor data, which accounts for person-specific attributes such as age, gender, height, and weight, is transmitted to the user through a "fatigue scorecard" visual dashboard.

"FATIGUE IS OFTEN OVERSIMPLIFIED AS A BINARY STATE—FATIGUE OR NON-FATIGUE. HOWEVER, FOR MANUFACTURING OPERATORS, A MORE NUANCED APPROACH IS REQUIRED. OUR SYSTEM RELIES ON PRIVACY-PRESERVING, UNOBTRUSIVE SENSING MODALITIES PAIRED WITH LIGHTWEIGHT ANALYTICS SUITABLE FOR ON-DEVICE DEPLOYMENT."

PING GUO

WHY IT MATTERS The system could help manufacturers preemptively address worker fatigue and reduce operational losses. It represents a significant step toward improving worker safety with potential applications in other sectors that involve physical motion and fatigue, including sports and medicine.

MILLIMETER-SIZED, DISSOLVABLE PACEMAKER

LED BY

Igor Efimov

Professor of Biomedical Engineering and Medicine

John A. Rogers

Louis Simpson and Kimberly Querrey Professor of Materials Science and Engineering, Biomedical Engineering, and Neurological Surgery

Yonggang Huang

Jan and Marcia Achenbach Professorship in Mechanical Engineering

THE PROBLEM Babies with certain congenital heart defects need temporary pacemakers after cardiac surgery, but conventional pacemakers are large and require surgery for implantation.

"About 1 percent of children are born with congenital heart defects; many of them require surgery and a temporary pacemaker. Now, we can place this tiny pacemaker on a child's heart and stimulate it with a soft, gentle, wearable device. And no additional surgery is necessary to remove it."

IGOR EFIMOV

THE IDEA A battery-powered, millimeter-sized pacemaker that can stimulate the heart autonomously. The pacemaker is smaller than a grain of rice and can be delivered through a catheter into the chest. A skin-interfaced wireless sensor, worn on the patient's chest, allows for on-demand operation. Made of bioresorbable materials, the pacemaker dissolves in the body after use.

WHY IT MATTERS Because the device is so small and can be implanted easily, the pacemaker could work well both for young patients and adult cardiac surgery patients whose bodies are not suited to traditional pacemakers.

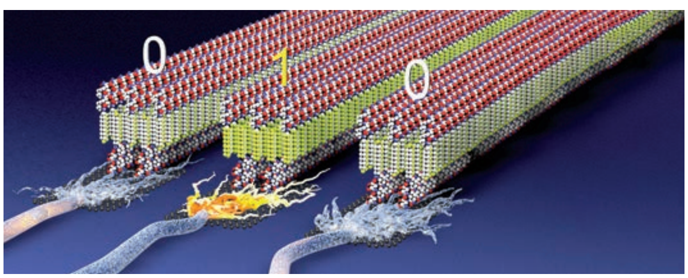
ELECTROACTIVE MATERIAL FOR WEARABLE TECHNOLOGY AND IMPLANTABLE MEDICINE

LED BY

Samuel I. Stupp

Board of Trustees Professor of Materials Science and Engineering, Chemistry, Medicine, and Biomedical Engineering

THE PROBLEM Ferroelectric materials—those with polar structures that can reverse orientation using external voltage—are traditionally hard, rigid, and often made from toxic substances. This makes using them impractical in electronic systems designed to integrate with the human body, such as biomedical implants or wearable technology.



"This is a wholly new concept in materials science and soft materials research. We imagine a future where you could wear a shirt with air conditioning built into it or rely on soft bioactive implants that feel like tissues and are activated wirelessly to improve heart or brain function." SAMUEL I. STUPP

THE IDEA A soft ferroelectric material made of flexible, nanosized ribbons built by thousands of molecules that could store energy or record digital information. This new material, reported in the journal *Nature* in October, integrates peptides with miniature molecular segments from polyvinylidene fluoride, a common plastic used in audio equipment that produces electrical signals when pressed or squeezed.

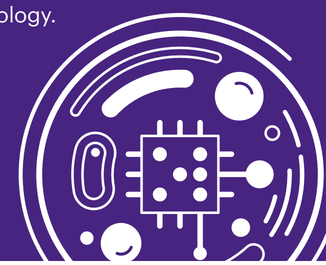
The result is a biodegradable material that requires incredibly low voltage to flip its polarity, which is useful for energy storage and in creating low-power electronics and nanoscale devices. Stupp also envisions attaching signals for cells in the peptide segments, offering a unique combination at the molecular level that generates materials that are both electrically active and bioactive.

WHY IT MATTERS With further development, these soft materials could be used in energy-efficient microscopic memory chips, sensors, and energy storage units—technologies that could be integrated into woven fibers to create smart fabrics or to power sticker-like medical implants for treating heart or brain function.

Biohybrid Systems

When Northwestern Engineering developed its new strategic vision in 2024, the leadership team developed three core pillars key to ushering engineering into the next era. One pillar, **Revolutionize the Methods of Engineering**, aims to help guide engineering into the future with new tools and methodologies.

One strategic priority that falls under this pillar is biohybrid systems. These include bioelectronics, biomaterials (including nanoscale materials designed to interact with the human body in new ways), and synthetic biology systems, which reengineer cells to help tackle issues in human health. To create these systems, Northwestern engineers are developing tools and defining future methods at the interface of engineering and biology.



From Lab Bench to Marketplace

Solutions that function in the lab but go unused in the marketplace do little to solve major challenges. This is why Northwestern Engineering has made translational research a priority. Since 2010, research from the nine faculty highlighted in this story has led to:

204 SUBMITTED DISCLOSURES OUTLINING NEW INNOVATIONS RELATED TO BIOHYBRID SYSTEMS

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168 PATENTS AWARDED FOR NEW INVENTIONS SPURRED BY RESEARCH

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15 STARTUP COMPANIES LAUNCHED IN THE AREAS OF BIOELECTRONICS, BIOMATERIALS, AND SYNTHETIC BIOLOGY

Design for the Community

In Design Thinking and Communication, first-year Northwestern Engineering students work with community partners to address real-world challenges with one-of-a-kind ideas.

Northwestern Engineering undergraduates have been collaborating with neighboring groups and individuals to address human challenges for nearly three decades.

In Design Thinking and Communication (DTC), a two-quarter course required of all first-year Northwestern engineers, students generate practical, one-of-a-kind solutions to improve people's lives. Since DTC's 1997 launch, students have demonstrated empathy and creativity alongside mathematics and scientific principles to tackle structured design challenges submitted by individuals, nonprofits, and industry members from across the Chicago area and around the world.

DTC's intimate, experiential process teaches students how to study a problem from multiple perspectives and properly frame a design challenge, laying a foundation for the remainder of their undergraduate studies.

Jointly taught by faculty from the McCormick School of Engineering and the Weinberg College of Arts and Sciences' Cook Family Writing Program, the course requires listening and observation followed by ideation and iteration. Students also fulfill their writing requirement by learning the value of clear communication as they share their ideas with stakeholders in design reviews, reports, and presentations.

The course shows students how the design process can deliver value and impact. "Before DTC, when I came up with a solution for any problem, I wasn't always thinking about who it affected and how it affected them," says Sahana Vandayar ('24). "But when you're assigned a real project partner, you think more about their experience."

Over the years, DTC students have crafted numerous innovations, from protective sleeping environments and adaptative video game controllers to flexible office arrangements and safer child strollers. Five recent projects grounded in human-centered design principles highlight how students' spirited, creative work has provided peace of mind, advanced quality of life, and enabled independence for Chicago-area community partners hungry for solutions.

> "Before DTC, when I came up with a solution for any problem, I wasn't always thinking about who it affected and how it affected them. But when you're assigned a real project partner, you think more about their experience." **Sahana Vandayar** '24

opposite Students present their final projects to clients and community members at the 2025 Design Thinking and Communication Expo.

Photo by Joel Wintermantle

Empowering safe, independent meal prep

PARTNER: NORTH CENTER

TEAM MEMBERS

Hyundo Jung
Computer Science '28, Mathematics '28

Ozan Kan
Computer Science '28

Heather Lee
Industrial Engineering '27

Kaden Xu
Computer Science '28

North Center, a community program that serves adults with developmental disabilities on Chicago's northwest side, believes its clients have a right to privacy and independence. To promote autonomous living, North Center program director Morgan Wilson teamed with DTC students to help clients heat their lunches safely using the in-house microwave.

"Many don't know how many minutes an item needs and pressed multiple buttons on the microwave while waiting, which created a potentially dangerous situation," Wilson says.

> "THIS HAS BEEN A BLESSING, AND WE USE IT EVERY DAY AT NORTH CENTER. IT'S A COOL ENGINEERING AND DESIGN IDEA GIVING OUR CLIENTS AUTONOMY AND INDEPENDENCE AS WELL AS ACCESS TO THE NUTRITION THEY NEED."
>
> **Morgan Wilson** Program Director, North Center

Through conversation with North Center staff and on-site observation, DTC students identified the four most frequently used cooking options. They then designed a simplified, four-button microwave interface linked to different time settings. Three of the buttons feature flame icons—one, two, and three flames related to cooking times of 30, 60, and 120 seconds, respectively. A fourth button with a television icon representing a TV dinner signifies a cooking option of six minutes. Once a user pushes a button, the microwave ignores any subsequent input to ensure safe heating operation.

"This has been a blessing, and we use it every day at North Center," Wilson says of the student-crafted microwave interface. "It's a cool engineering and design idea giving our clients autonomy and independence as well as access to the nutrition they need."

Making learning robotics more engaging and fun

PARTNER: MISERICORDIA

TEAM MEMBERS

Mufaddal Badri
Chemical Engineering '28

Connie Gillum
Biomedical Engineering '28

Isaiah Hashimoto
Computer Science '28

Leo Orbea
Biomedical Engineering '28

Thomas Surridge
Mechanical Engineering '28

At Misericordia, a Chicago-based nonprofit, developmental training instructors like Jeremy Wyatt are always seeking accessible, enriching educational tools for the more than 600 children and adults with developmental disabilities it serves on a 37-acre campus.

Misericordia's robotics curriculum, however, was struggling to engage residents and provide sufficient academic depth. The Kids First Coding & Robotics learning tool, for example, taught basic robotics and problem-solving skills, but failed to challenge students as it once did. Wyatt needed a more engrossing, easy-to-use educational tool with the ability to teach additional subjects. A team of five DTC students rose to the challenge with the Kids First Robot–Explorer's Edition, an expanded, multifaceted version of the resource integrating geography with coding and greater sensory engagement for enhanced learning and independence.

Explorer's Edition simulates the experience of flying over a map, providing users dynamic interaction with geographical features to make learning fun and intuitive. Using a 3D-printed adapter, students connect a magnetic toy plane to the base of a robot.

The team also created a transparent box—the so-called "sky platform"—equipped with a map of recognizable geographic locations, a US state map for example, on its floor. After programming a set of directions into the robot, users place the robot on the sky platform and set out on an adventure to discover the world around them.

Impressed with the solution, Wyatt implemented the Kids First Robot–Explorer's Edition into the Misericordia curriculum. He says residents enjoy the expanded abilities of the robots and reports increased participation with the robotics kits.

Improving health and safety in special education

PARTNER: NILES TOWNSHIP DISTRICT FOR SPECIAL EDUCATION

TEAM MEMBERS

Wesley Lu
Mechanical Engineering '27

Satviki Madaan
Computer Engineering '27

TJ Tipton
Mechanical Engineering '27

Jose Vergara
Mechanical Engineering '27, MS Computer Science '27

Michelle Van Acker, an occupational therapist at Niles Township District for Special Education (NTDSE), presented DTC students with a unique challenge. A four-year-old boy attending NTDSE compulsively put his hands in his mouth. The oral fixation led to calluses and skin irritation on the boy's hands and saliva buildup around his torso. Van Acker tasked students to design a safe, nonrestrictive, washable device that would prevent damage to the young boy's hands and minimize the risk of illness.

"We wanted a healthy, developmentally appropriate solution that wouldn't restrict the student's movement or limit his independence," says Van Acker, adding that existing options, such as mittens, knuckle guards, and hand-splints were inadequate.

"THIS SOLUTION ALLOWED OUR STUDENT TO REMAIN INDEPENDENT AND RETAIN HIS MOVEMENT WHILE STAYING CLEANER, HEALTHIER, AND SAFER."

Michelle Van Acker Occupational Therapist, NTDSE

The DTC students responded with a two-pronged concept. First, they fashioned a device called the HandyGuard out of a soft, food-safe plastic material. Wrapped around the hand and attached with Velcro, the transparent device—akin to a glove without fingers—includes a ring of absorbent material to block saliva from reaching the hand. It prevents the boy from sucking his hands while still enabling sensory stimulation.

Next, they crafted a protective shield, called ProtectiBib, from incontinence pads and attached it using magnets to cover the boy's upper body. It absorbs saliva coming from the boy's mouth and tracheostomy tube.

"This solution allowed our student to remain independent and retain his movement while staying cleaner, healthier, and safer," Van Acker says.

Reengineered kickstand improves cyclers' experience

PARTNER: ENVISION UNLIMITED

TEAM MEMBERS

Amelia Hasting
Industrial Engineering '27

Elsie Hayduk
Manufacturing and Design Engineering '27

David Kovach-Fuentes
Computer Science '27

Alvin Xu
Computer Science '27

At Envision Unlimited, a Chicago-based nonprofit serving adults with intellectual and developmental disabilities, a well-established adaptive cycling program enables participants to interact with the community, build relationships, explore, and enjoy heightened independence. However, a persistent issue with the organization's fleet of 30 tandem bikes proved particularly irksome for users: kickstands were prone to failure and user error.

Convinced that a more intuitive, easy-to-use kickstand would benefit riders and deliver a more pleasant experience, Envision Unlimited program coordinator David Pufundt turned to DTC students to create a more natural, functional option.

Drawing inspiration from more robust motorcycle kickstands, which must handle this vehicle's significant weight, a team of DTC students obtained one before testing different attachment mechanisms, modifications, and placement spots on a tandem bike. Their solution, the prototype Spring Kickstand, maintained structural integrity while avoiding rider interference—just the solution Pufundt needed for Envision Unlimited's riders.

"DTC students brought a perspective we didn't have, and that led to these kickstands that will benefit us on every ride we take moving forward," Pufundt says.

Fixing a flaw to protect valuable tools

PARTNER: SHIRLEY RYAN ABILITYLAB

TEAM MEMBERS

Evan Le
Industrial Engineering '26

Chris Leung
Electrical Engineering '27

Charlie Single
Mechanical Engineering '27

Riley Thornburgh
Chemical Engineering '27

For occupational therapists at Shirley Ryan AbilityLab, hand dynamometers—which measure grip strength—provide objective data on an individual patient's recovery. But the frequently used tools broke far too often when dropped due to cases that were not properly latched. With repair and replacement costs mounting, the Chicago-based rehabilitation research hospital asked DTC students for help.

Shirley Ryan AbilityLab occupational therapists imagined the students might create something akin to a smartphone case for the dynamometers. Following extensive questioning, observation, and study, the students instead developed a much different, albeit simple and powerful solution.

The students retrofitted an existing dynamometer case with magnets and an additional handle to prevent the cases from accidentally opening. Through multiple rounds of testing, they discovered the right blend of strength and placement to seal the case without challenging therapists' ability to access the tool when needed.

"The design blew us away," says Joann Prekezes, a former occupational therapist at Shirley Ryan AbilityLab. The hospital's team members immediately began exploring the feasibility of retrofitting all their dynamometer casings to the DTC team's design.

DANIEL P. SMITH

Got a Challenge That Needs Solving?

Design Thinking and Communication invites organizations and individuals to submit challenges any time. Ideal topics could involve:

- Devices that leave users unsatisfied
- Accessibility challenges requiring fresh perspectives and ideas
- Processes that could be more efficient

What's in it for you?

- Dedicated teams of engineering students working with you
- Proof of concept prototypes and documentation
- Compensation for your time and feedback during the process

Time commitment?
Just 5–10 hours over the course of 10 weeks.

CONTACT THE DTC TEAM TO LEARN MORE.

CLASS NOTES

Nurturing New Ventures

TECHNOLOGY ENTREPRENEUR **DENNIS YANG** USES HIS EXPERIENCE TO HELP OTHER STARTUPS SUCCEED.

When Dennis Yang ('95) joined online learning platform Udemy as president and chief operating officer in 2012, it was a small startup with about 15 employees. By the time he left as CEO in 2017, the company was worth nearly $1 billion with more than 15 million students and 20,000 contributing instructors around the world.

"We democratized access to education and were able to grow extremely quickly by serving an unmet global need," Yang says. "We also built a company culture and an organization that people had tremendous pride in, where they developed individually, professionally, and personally."

Yang understands the challenges of learning new skills to perform well in any position. After earning a chemical engineering degree at Northwestern, he worked as a consultant, teaching himself how to interpret advanced financial statements. He went on to work in venture capital and with a startup before pursuing an MBA at the Stanford Graduate School of Business to learn about sales, marketing, and business strategy.

Afterward, he expanded his skill set in product manager roles, then later served in expanding operational roles before joining Udemy, where he found his niche. "I fell in love with the mission," Yang says. "This product was designed for people like me who are curious and want to learn. With a tremendous amount of hard work and luck, we had incredible success."

Yang leveraged that experience to launch his own education technology venture, Modal Learning, with fellow Udemy executive Darren Shimkus in 2021. The online learning platform helps companies develop employees' technical and AI skills. Its courses provide project- and lab-based learning supported by coaches and a community of learners and practitioners.

Today, Yang focuses most of his time as an adviser, investor, and board member to early-stage companies in technology, mentoring fellow entrepreneurs and nurturing startup ventures.

"There's no playbook to tell you how to do it," Yang says. "It's very experiential, it's brutal, and frankly, it's not meant for everyone. Since I have the benefit of going through that experience, I love to give back and share that wisdom."

He credits Northwestern with helping him develop the tools to build entrepreneurial ventures. "I learned problem-solving skills, structured thinking, and grit to get through periods of constant learning," he says. "The process is uncomfortable because you're always on the edge of growth. That engineering mindset is incredibly valuable, but you also have to develop sales, empathy, and leadership skills."

Crediting his success to his Northwestern experience, Yang gives back by serving as a Northwestern Alumni Regent and member of the Farley Center for Entrepreneurship and Innovation's advisory board. His recent gift also established the Yang Family Curriculum Development Fund to support expanded entrepreneurship courses and workshops as well as experiential learning opportunities.

"I feel lucky to be where I am today, and with that good fortune, you feel an obligation to give back to the next generation and share the lessons you've learned along the way," Yang says. "I'm a huge believer in entrepreneurship, and I'm more than happy to do everything I can to support that at Northwestern. It's a highlight for me."

SARA LANGEN

AN UNEXPECTED PATH TO PATIENT CARE

JENNIFER GLONKE STEWART APPLIES THE SKILLS AND MINDSET SHE DEVELOPED AS A NORTHWESTERN ENGINEERING STUDENT AND NCAA DIVISION I ATHLETE TO LEAD A PATIENT-CENTERED APPROACH TO CLINICAL RESEARCH.

Jennifer Stewart ('04) balanced two demanding yet complementary roles at Northwestern: biomedical engineering undergraduate and student-athlete on the University's softball team.

In the lab, teamwork and communication were crucial for complex problem-solving. On the softball field, consistency, discipline, and adaptability helped build muscle memory to respond to split-second situations.

"In both places, I learned that making a little adjustment can translate into significant results," Stewart says. "I learned to manage my time effectively—how to balance priorities, how to deliver even in a crunch, how to turn my focus on a dime."

Now, Stewart applies the same analytical, mid-game mindset as executive director of clinical data sciences at Premier Research, a clinical research, product development consulting, and clinical technology company that provides strategic solutions in oncology, neuroscience, immunology, and rare disease therapeutics, medical devices, and diagnostics. She leads a global team of nearly 200 data scientists that manages clinical trial data used by pharmaceutical, biotechnology, and MedTech clients to evaluate whether investigational treatments are safe and effective.

As an undergraduate, clinical research wasn't on Stewart's radar. She had planned to practice medicine. Her adviser, professor Matthew Glucksberg, recommended she take the biomechanics and rehabilitation pathway in the biomedical engineering program. That led to a pivotal internship with T. George Hornby at the Rehabilitation Institute of Chicago (now the Shirley Ryan AbilityLab) where she collaborated on a team testing the efficacy of the Lokomat®, a rehabilitation robot designed to help patients recovering after stroke and spinal cord injury strengthen their muscles and improve their walking ability.

"The coursework I was taking in my undergraduate curriculum helped me understand the rigor of our research approach," Stewart says. "We were focused on patient care while being very intentional about consistency, data validation, and quality control."

The experience changed Stewart's career trajectory, but not her commitment to patient care. Today, she gets goosebumps thinking about the long-term impact of her team's work at Premier Research, recalling times when she's heard from patients about how treatment changed their lives. "It's meaningful to know that, even though I'm not hands-on treating a patient, I am having an impact on their journey," Stewart says.

Grateful to her mentors for introducing her to alternative pathways, Stewart is committed to paying it forward, guiding students and early-career professionals and encouraging them to cast a wide net.

"Success comes from surrounding yourself with brilliant minds and broad perspectives," Stewart says. "The decision you make today about what you're studying will not force you into a narrow box in the future—the exact opposite. There are many options to build on the foundation of an engineering education, even if you're not working as an engineer."

MICHELLE MOHNEY

A STORIED CAREER

Following her softball career at Northwestern, Stewart continued to play competitive slow-pitch softball for many years. In November 2024, she was inducted into the Illinois United States Specialty Sports Association Hall of Fame in recognition of her achievements. "Made to Order," a slow-pitch team Stewart played on for nearly a decade, was also recognized as a 2024 Illinois USSSA Hall of Honor team.

"SUCCESS COMES FROM SURROUNDING YOURSELF WITH BRILLIANT MINDS AND BROAD PERSPECTIVES."

Aptos Labs CEO **Avery Ching** is helping define how money moves worldwide.

Pushing the boundaries of global finance

Avery Ching ('02, PhD '07) is helping build the future of finance. As cofounder and CEO of Aptos Labs, he's developing a Layer-1 blockchain to enhance scalability, security, and transaction speed while providing universal and centralized access to decentralized assets for developers.

"We're on the cutting edge of what can be done in this space, and every time we push a boundary, it enables some new use case that wasn't possible before," Ching says. "It's exciting—we get to lead the future."

Under his leadership as chief technology officer and now CEO, Aptos has formed partnerships with Google, Microsoft, Mastercard, BlackRock, and Franklin Templeton. Offering high throughput and low latency to support mass-market applications, Aptos holds the top four records for daily blockchain transactions.

"We're on the verge of getting into Web 3.0, where you'll see new companies start to emerge and build out billion-dollar-plus businesses," Ching says. "Being on the cusp of that and driving innovation is something that gets me super pumped every day."

Carving a path

Ching's interest in computer engineering began at Northwestern. Unsure of what he wanted to study as an undergraduate, Ching appreciated Northwestern's flexibility in letting students explore different subjects. "It's a very open environment to pursue your individual interests," he says. "That's something I really valued."

After taking an engineering course on circuit design, Ching was hooked. He enjoyed the hands-on approach to technology and found his niche in computer engineering, where he met his mentor and adviser Alok Choudhary, Harold Washington Professor of Electrical and Computer Engineering and Computer Science. Ching describes Choudhary as a "huge influence" on his decision to pursue a PhD in the subject. "He was instrumental in helping me get excited about high-performance computing," Ching says.

After earning his PhD, Ching worked at Yahoo for four years, focused on web search and Apache Giraph, an open-source, iterative graph processing system built for high scalability. Leaders at Facebook (now known as Meta) noticed Ching's work and in 2011 asked him to join the company; he did, and spent more than a decade there.

"When I started with Facebook's data infrastructure team, we were a small team of 20 to 30 people," he says. "When I left, we were about 200. That was a really transformative journey to grow my career but also grow myself individually."

Ching served as Meta's overall tech lead for batch processing teams, including those responsible for Apache Spark, Apache Giraph, Facebook Hive/Hadoop (Corona), distributed scheduling, and the unified programming model for pipelines. These technologies provide underlying analytics for all Meta products, scale to hundreds of thousands of machines, and enable experiences for billions of consumers.

Ching's focus transitioned to blockchain when fellow Northwestern alumnus Hui Ding (MS '06, PhD '09) convinced him to work on Meta's Libra and Diem projects to support payments around the world on a decentralized blockchain. Ching led Meta's crypto platform team focused on blockchain technology. "It was a really fantastic experience to be like a startup within this large company," he says.

Taking initiative

That experience inspired Ching and the founding team to come together and announce Aptos Labs in 2022. The entrepreneurial venture leverages the open-source technology and programming language developed for Diem, a project Meta discontinued. The platform raised more than $400 million in venture capital from investors such as Andreessen Horowitz (a16z), Coinbase Ventures, and PayPal.

"We started looking for funding with the blessing of Facebook," Ching says. "It's been a great journey with investors who share the vision of a decentralized internet and want to put money behind it to help us succeed."

Ching is passionate about open finance, which gives anyone the ability to access financial infrastructure and assets around the world at any time. It also allows developers to integrate financial products without requiring permission.

> "Always taking initiative, sharpening your ideas, and then turning them into practice is something I got out of my PhD."

"It's transformative when it comes to impacting society positively now that we can have money movement happening for anybody in the world in under a second at a hundredth of a cent," he says. "That's an incredible new technology that can change this world and open up economic borders."

Ching credits Choudhary's guidance with helping him develop the sense of responsibility and independence that fuels his work.

"I learned to be proactive about what do I want to solve, what challenges am I trying to address, and what's the best solution," he says. "Those lessons translate well into taking initiative, whether you're at a company or starting your own business. Always taking initiative, sharpening your ideas, and then turning them into practice is something I got out of my PhD."

SARA LANGEN

IN MEMORIAM

John A. "Mac" McQuown
Photo by Jim Prisching

Horace Yuen

JOHN A. "MAC" MCQUOWN

John A. "Mac" McQuown ('57), financial innovator, environmentalist, and generous benefactor, passed away on October 22, 2024. He was 90 years old.

McQuown pioneered the use of data analysis to create the first equity index funds. He was also a successful entrepreneur in the financial services, technology, and fine wine industries. He and his wife Leslie supported interdisciplinary research across Northwestern, including with gifts to support the Northwestern Institute on Complex Systems and to help establish the Julio M. Ottino Professorship. In 2017, he received the Northwestern Alumni Medal.

"Mac's drive to innovate led him to truly change the world, and then he used that success to accelerate further research into areas that he knew were important to our future," said Christopher Schuh, dean of the McCormick School of Engineering.

PROFESSOR EMERITUS HORACE YUEN

Horace Yuen, professor emeritus of electrical and computer engineering, passed away on January 16, 2025. He will be remembered as a leading scholar and pioneer in the field of physics- and mathematics-based quantum and classical cryptography.

During his 41-year career at Northwestern, Yuen was a leader in theoretical quantum optics and communication, the foundations of quantum physics, cryptographic protocols, information theory, and new quantum devices.

Among his foundational research accomplishments in the field of quantum cryptography, Yuen received a patent for developing an "Ultra-Secure, Ultra-Efficient Cryptographic System." The system extends a short, shared secret key into a long, extended key that selects a quantum or classical signal set. The security-level objective is achieved by adjusting the strength of each signal in the set according to the total number of signal sets.

Yuen also developed a cryptographic technique called the decoy bits method with near ideal information-theoretic security in both quantum and classical key generation and data encryption. The DBM encryption system inserts random bits into a data sequence and subsequently discards the decoy bits during the decryption process.

Yuen earned his bachelor's and master's degrees and his PhD in electrical engineering from the Massachusetts Institute of Technology and received several honors throughout his career, including being named among the inaugural recipients of the biennial International Quantum Award for "outstanding achievements in quantum science research."

"Horace was a true scholar who made deep theoretical contributions to complex problems," said Randall Berry, John A. Dever Chair of Electrical and Computer Engineering. "He will be missed."

Maurice C. Prottengeier '44
Walter R. Derlacki '45
Louis R. Bindner '46
Winifred M. E. Hutton '47
Donald W. Neukranz '50
Alexander F. Leondis '52
William M. Willison '52
Andrew G. Anderson Jr. '53
Sarkis S. Sarkisian '53
John R. Wagner '53
John M. Johnson Jr. '54
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Thomas A. Risch '55
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Erwin L. Carls '57
Ralph H. Larson '57
John A. McQuown '57
J. Charles Forman '57, '60
Norman J. Franz '57, '58
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Clarence J. Maday '60
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Randall L. Bartell '62
Julian J. Brix '62
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Sherman M. Shand '63
Jay Warshawsky '63
William J. Byrne Jr., '64, '68, '81
Theodore R. Watson '64
Rafael P. Maramba '65
Ira Birnbaum '67
Kenneth W. Chilton '67, '69
Jeffrey L. DuRocher '67
W. James Hadden Jr. '68, '71
Aivars J. Bokalders '69, '75
Jon L. Phillips '69
Bruce G. Wilson '70
David G. Dickerson '74, '85
Elizabeth B. Kennard '75
Carol Anita McIntosh '75
Timothy J. Scale '75, '80
Daniel Keith Piper '76
James J. D'Ambrisi '79, '91
James Tsai-An Hsu '79
Andrew S. Lasser '79
Thomas Demos '80
Mark D. Schuman '82
Steven D. Mohan Jr. '89
Barry Keith Law '94
Simon Gross '07
Max Jordan Chiswick '08
Shashwat Ajit Adhikari '16
Douglas W. Weaver '17

DON'T BE DUPED

How to Spot Deepfakes

PROFESSOR V.S. SUBRAHMANIAN SHARES FIVE TIPS TO HELP AVOID GETTING TRICKED BY MODIFIED DIGITAL ARTIFACTS.

Deepfakes—digital artifacts including photos, videos, and audio that have been generated or modified using AI software—often look and sound real.

Deepfake content has been used to dupe viewers, spread fake news, sow disinformation, and perpetuate hoaxes across the internet. And though not all deepfakes are bad, the negative ones get the headlines and can have severe consequences.

V.S. Subrahmanian, Walter P. Murphy Professor of Computer Science at Northwestern Engineering, has five pieces of advice to avoid getting duped by dangerous deepfakes.

1. Automatically question what you see and hear

Anyone with internet access can create a fake, so anyone with internet access might become a target for deepfakes.

"Rather than try to detect whether something is a deepfake or not, basic questioning can help lead to the right conclusion," says Subrahmanian, founding director of the Northwestern Security and AI Lab and faculty fellow at Northwestern's Buffett Institute for Global Affairs.

2. Look for inconsistencies

For better or for worse, deepfake technology and AI both continue to evolve at a rapid pace. Ultimately, software programs will be able to detect deepfakes better than humans, Subrahmanian predicts.

For now, there are some shortcomings with deepfake technology that humans can detect. AI still struggles with the human body, sometimes adding an extra digit or contorting parts in unnatural ways. The physics of light can also cause AI generators to stumble.

3. Break free of biases

It's human nature to become so deeply rooted in preconceived notions that we take them as truth. In fact, people often seek out sources that confirm their own notions, and fraudsters create deepfakes that reinforce previously held beliefs to achieve their goals.

"Some people are more likely to consume social media information that confirms their biases. I suspect this filter-bubble phenomenon will be exacerbated unless people try to find more varied sources of information," Subrahmanian says.

"THERE ARE A LOT OF POSITIVE APPLICATIONS OF DEEPFAKES, EVEN THOUGH THOSE HAVE NOT GOTTEN AS MUCH PRESS AS THE NEGATIVE APPLICATIONS."

V.S. Subrahmanian
Walter P. Murphy Professor of Computer Science

4. Set up authentication measures

Audio deepfakes have been used to trick people into not voting by simulating a candidate's voice. This trick can get personal, as scammers have tried to steal people's money by recreating a relative's voice and calling and saying they need funds.

To avoid falling for this ruse, Subrahmanian suggests setting up authentication methods with loved ones. That means asking specific questions only that person would know, such as where they recently ate, or even a code word.

5. Understand that social media platforms can only do so much

Social media has changed the way people communicate with each other. They can share updates and keep in touch with just a few keystrokes, but their feeds can also be filled with phony videos and images.

Subrahmanian said some social media platforms have made admirable efforts to eliminate deepfakes. However, suppressing deepfakes could potentially suppress free speech. Subrahmanian recommends checking websites such as PolitiFact to gain further insight into whether a digital artifact is a deepfake or not.

BRIAN SANDALOW

Northwestern | McCORMICK SCHOOL OF ENGINEERING

Robert R. McCormick School of
Engineering and Applied Science

Northwestern University

Technological Institute
2145 Sheridan Road
Evanston, Illinois 60208–3100

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WORLD'S SMALLEST PACEMAKER

Northwestern engineers created a pacemaker so tiny that it can fit inside the tip of a syringe and be noninvasively injected into the body. Smaller than a single grain of rice, the pacemaker is paired with a small, flexible, wireless, wearable device that mounts onto a patient's chest to control pacing. When the wearable device detects an irregular heartbeat, it automatically shines a light pulse to activate the pacemaker. The device was developed by Professors John Rogers, Igor Efimov, and Yonggang Huang. Read more on page 22.

Photo by Northwestern University