ENGINEERING @

Northeastern

SPRING 2021

AI in Healthcare

FROM THE DEAN

It is my honor to be leading this great College of Engineering at Northeastern as your new dean. Since I joined in March, I have felt the vibrancy of the people, students, and environment. I look forward to continuing our bold education and research efforts to further propel the college forward. Read more about my background in the Q&A article on the next page.

Education is the great equalizer. It's a sentiment established in 1848 by Horace Mann and lives true to this day. In the College of Engineering, we are committed to developing the next generation of engineers that are reflective of our global society. In the article, "Changing the Face of Engineering," we shine light on a few of our students' journeys and how our innovative programs have made a difference in their lives—and how they are giving back.

As I said previously, our College is vibrant! It is also resilient. Amid the pandemic, like our faculty, our students contributed to making a difference in a variety of ways, from founding a startup to produce face shields to working on co-op on a COVID vaccine. Also, I am very proud to share that six of our faculty received National Science Foundation CAREER Awards this year—more than ever before. All this and more can be found in the "Campus Beat" section.

With an engineering strength in artificial intelligence coupled with Northeastern's newly established Institute for Experiential AI—College of Engineering researchers are working on interdisciplinary AI solutions across disciplines, from robotics to climate change. With such a broad scope, in this magazine edition we drill down into the many efforts underway focused on AI in the healthcare industry. See page 24.

We continue to innovate in all we do with a focus on transforming the world. Read about our dual PhD program spanning continents, and our one-of-a-kind drone testing lab and new entrepreneurship facilities at the Innovation Campus, among others.

We are very thankful for the generous philanthropy of our alumni and friends. No gift is too small and all contribute to our ability to support students and faculty with research capabilities, activities, scholarships, and so much more. Beginning on page 52, we highlight gifts to further opportunity for historically underrepresented students, as well as some inspiring donor stories.

Our Northeastern community is looking forward to a more normal fall 2021 semester. Wishing all of you renewed hope post-pandemic and well wishes in the year ahead.

Gregory D. Abowd, Dean
College of Engineering
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Welcoming Our New Leader

Gregory D. Abowd joined Northeastern University as Dean of the College of Engineering and Professor of Electrical and Computer Engineering in March 2021. Prior to Northeastern, he was a Regents' Professor and held the J.Z. Liang Chair in the School of Interactive Computing at the Georgia Institute of Technology, where he also served as Associate Dean of Research and Space for the College of Computing. Abowd is an internationally renowned and highly cited scientist, well known for his contributions in the general area of Human-Computer Interaction (HCI) and specifically for his groundbreaking research in ubiquitous computing.

View Dr. Abowd's full background
coe.northeastern.edu/people/abowd-gregory

TELL US A BIT ABOUT YOUR RESEARCH CAREER. WHAT HAVE YOU BEEN WORKING ON?

Well, in general, when I got to Georgia Tech, I was a particular kind of researcher and I changed rather drastically. Within a year, I was very much influenced by the writings and vision of [computer scientist] Mark Weiser, who is considered the founding father of ubiquitous computing.

His vision was a form of computing that was off the desktop, that included a sensor-based exploration of what our world might be like. And this was a vision that he expressed in the late 1980s! It was a vision of what our world might be like if computers became more prevalent than they were at that time, if they were more than just desktops and personal devices–if they became more part and parcel of our everyday activity and were embedded in our physical environment in such a way that we didn't even notice where they were all the time.

I was revisiting that vision around 2015-2016, in the context of new technological capabilities, particularly in additive manufacturing, and in the development of nano-electronic devices.

COULD YOU EXPLAIN THAT A BIT MORE?

Yeah, so let's take the phrase "internet of things." So, when we say "internet of things" today, it's typically about taking existing pieces of technology and adding a network capability to them so they can connect with other pieces of technology. We are not talking about say, a Post-It note, or a cup, or a shirt, or a pair of glasses; we're not thinking about what comes to mind for most people when you say "thing."

I'm interested in making things–entities that we are familiar with in our everyday physical world–that have the capabilities of sensing, computing, and communicating, so that you can achieve Weiser's vision.

He had two very eloquent sentences at the beginning of his book, "The Computer for the Twenty-First Century." He writes, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life, until they are indistinguishable from it."

He meant that metaphorically, but you can actually start to think about that more literally, by manufacturing computational capabilities into "things"; by literally weaving them in or manufacturing them as part of how you produce a piece of paper or Post-It note. That's what I mean, that's what we've been exploring in my lab, and it's starting to grow around the world, this whole notion of computational materials.

THINKING BIG PICTURE, WHAT ARE SOME OF THE CHALLENGES OR ISSUES IN THE WORLD TODAY THAT YOU'RE EAGER TO ENCOURAGE NORTHEASTERN STUDENTS TO DIG INTO?

Oh, there's a ton of them. Data engineering is a huge industry, the cloud, and Big Data, and all that. And big companies are investing a lot of money, to the tune of maybe a billion dollars a month, to maintain and build data centers. And this is projected to be something like 20 percent of the world's energy supply to feed the power needs of these data centers.

So that is seriously an engineering challenge to say, "How can we reduce the energy reliance for what appears to be an insatiable desire to get more data, and to handle that more data and to infer more things from that data?" That's why I'm so interested in these kinds of self-sustaining computational solutions.

But more important is what this allows us to do. In parts of the world where power is not an assumed resource, you need self-sustainable capabilities. And, the price of computers, as much as it's gone down, is still not inexpensive. So to address those kinds of grand-scale problems, you really do need very cheap, self-

sustaining solutions to gather that kind of information.

Additionally, any time we're talking about collecting data, we need to be thinking about the kind of world we want to enable—how we put the right kinds of checks on it.

On the more humanist perspective, I'm very fortunate to be raising two boys on the autism spectrum. That has infused in me a kind of compassion and understanding of neurodiversity. People are wired differently, they think about the world differently. And it is almost always the case that you cannot discern how someone is wired by just observing them or talking to them.

So, if someone does something that seems odd to you, or unnatural or inappropriate, our initial reaction is to think negatively about them, as opposed to considering that they just might think differently about the world.

WHAT DO YOU SEE FOR THE FUTURE OF THE COLLEGE OF ENGINEERING? HOW DO YOU PLAN TO LEAD THE COLLEGE?

Well, I've talked quite a bit about my research and computation materials, and it's true that I will remain as much as possible a very active researcher—that curiosity doesn't die, you know.

But I realized that you cannot be selfish in this kind of position, you have to be thinking about what's good for the College of Engineering, what's good for Northeastern. This is something that's influenced by my upbringing. I'm the 10th of 12 children in my family, so being in a large family, I understand that it's never just about me, it has to be about the community.

I'm coming to Northeastern to help it continue to thrive and to help it to strive to be better.

HOW DO YOU PLAN TO DO THAT?

Let's start with co-op.

When you are trying to learn something, it helps a lot to learn in a variety of different modes. You have theoretical, foundational learning that you do in the classroom, but then to understand how those lessons are relevant outside the classroom—that's what the co-op experience is all about, to me. You learn how your skills apply to other parts of the world in useful ways, and when you're exposed to other parts of the world, you recognize what else you still need to learn.

So I would hope what really comes out of a co-op experience is that people realize that for the rest of your life, you're going to be doing both of these things: You're going to be learning new things, and you're going to be understanding how it matters in the context.

And that never ends; you don't end your education, then go into the workforce, and never learn any new things. So, to me, that's really the strength of this kind of experiential learning—this play between learning and doing and understanding how the things you learn are relevant not only to enriching yourself intellectually, but helping you be a connected player in the world.

YOU MENTIONED THIS IDEA OF BEING CONNECTED TO THE WORLD. HOW WILL YOU FOSTER INDUSTRY PARTNERSHIPS FOR THE COLLEGE OF ENGINEERING?

Yes, so clearly it's important from the experiential learning perspective to have partnerships with industry leaders, but I'll also be a little broader than just talking about industry. You have to take into account your local situation, and build off the strengths of what's local.

So when you talk about industry, particularly with regard to Northeastern's Boston campus, you look at what the strengths are locally. In Boston, there are tons of industries: medical, robotics, biotechnology, the list goes on. My view is not to ignore the local expertise and industry, even though we're in this highly connected world where we have access to people and ideas everywhere.

Of course, we just spent a year in a pandemic where we've been forced to be remote, but I think fundamentally, it is easier and more natural for us to work face-to-face with people. And when people are closer to you, you have more of an affinity with them.

All this is to say, understand your local environment and take advantage of its strengths.

HOW DO YOU PLAN TO ENSURE A RICH DIVERSITY AMONG STUDENTS, FACULTY, AND STAFF IN THE COLLEGE?

Well, as I mentioned earlier, I have a personal experience with neurodiversity, which, I think, is a particularly interesting form of diversity, because it's for the most part invisible. And when it makes itself visible, it's usually highlighting differences that people have negative reactions to. But, having raised two boys who are neurodiverse, I'm highly attuned to, and very sympathetic about, people's neurodiversity.

And that's crucial because having different perspectives really helps you think through tough problems. When I was talking earlier about being an out-of-the-box thinker—because I was never in the box—that's just admitting that diverse perspectives help you come up with different ways to attack problems. And there are problems that have been with us for a long time, and are begging for different perspectives. Clearly, if a problem still persists, then it requires different kinds of thinking to solve. And people who come from different backgrounds, different experiences, a different part of the world, different cultural experiences, different religious experiences, have a different way they're wired. All those can all help think creatively about particular problems. One way to nurture a diverse environment is to ensure that there are appropriate role models. So, you need faculty who represent all these different perspectives, and you also need faculty who are excellent and feel supported. And you've got to balance all of these things. ■

By Molly Callahan, News@Northeastern

What's Inside

ENGINEERING @ Northeastern
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Questions and Comments

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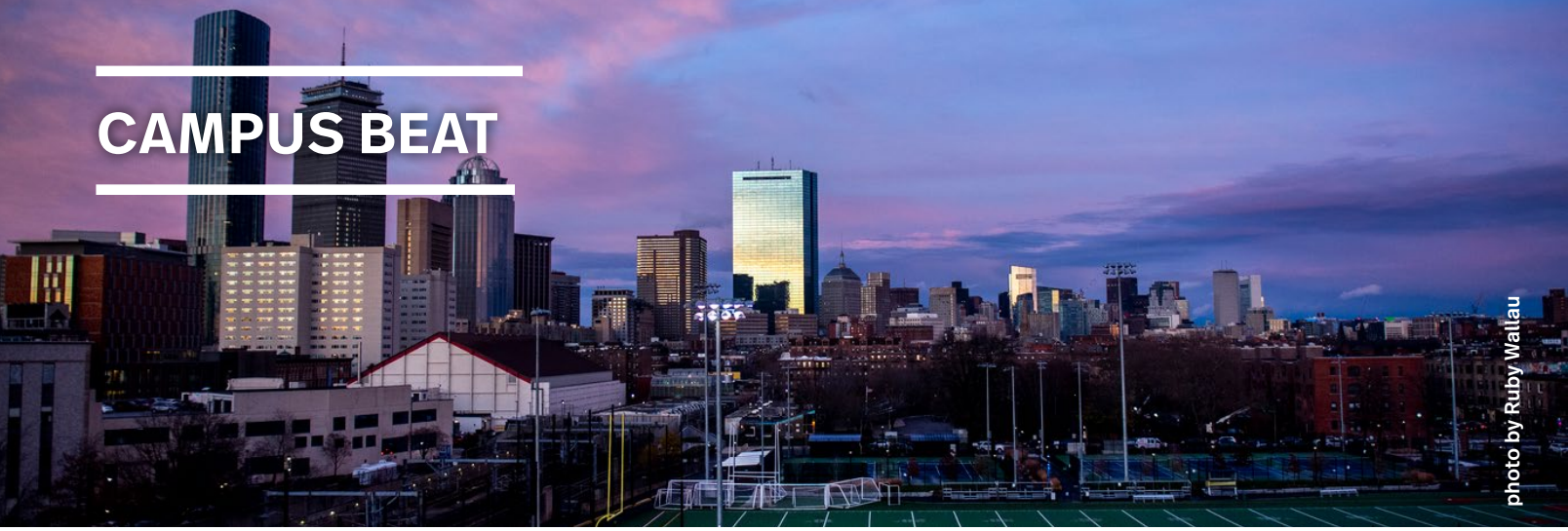
MAIN FEATURES

SHORT READS

ON THE COVER

Northeastern's new Life Sciences Testing Center at the Innovation Campus in Burlington, Massachusetts, processes coronavirus tests. It has received state and federal certifications to conduct the complex molecular diagnostics tests that can determine whether someone has been infected with SARS-CoV-2—the coronavirus behind the COVID-19 pandemic. Photo by Matthew Modoono/Northeastern University



COVID-19: Students Making a Difference

photo by Mathew Modoono

One week after the pandemic forced him to leave the Boston campus in March 2020, **Max Seidel,** E'23, mechanical engineering, joined with a friend to launch Atlanta Face Shields from his hometown. The group has donated over 5,000 shields to hospitals, police departments, schools, and other organizations mainly in Georgia, though some were shipped as far away as Mexico City and Pittsburgh. Upon returning to campus in fall 2020, Seidel continued the face shield effort with his two 3D printers in his single dorm room. Atlanta Face Shields has also expanded to the University of Alabama, Georgia Tech, University of Maryland, and California State University San Marcos. The charity was inspired by a call to action by Tikkun Olam Makers, an Israeli organization of communities in 24 countries that helps the poor, the elderly, and people with disabilities. Seidel, who is a College of Engineering Healy Scholar, is creating a chapter of the organization at Northeastern, which will enable fellow students to join him in creating and distributing face shields along with participating in other Tikkun Olam Maker events.

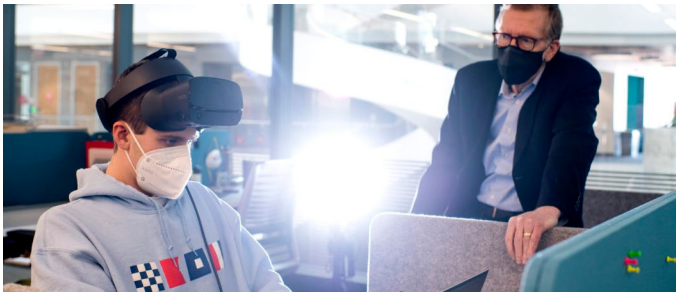
James Sinoimeri, E'21, ME'21, chemical engineering, worked at Moderna as an mRNA process development co-op. Moderna is a biotech company headquartered in Cambridge, Massachusetts that developed the COVID-19 vaccine known as mRNA-1273. Sinoimeri's primary responsibilities at Moderna related to the scale-up, characterization, and optimization of the manufacturing process for mRNA-1273. More specifically, he was tasked with studying separation and reaction mixing unit operations to cut down on processing times and increase product yields. Sinoimeri's co-op was full time in fall 2020 and continued part-time through the spring 2021 semester, working on similar projects for Moderna's COVID-19 variant booster shot and seasonal flu vaccine. He is joining Moderna full-time as a process development engineer upon graduation to continue his work.

While on co-op at Beth Israel Deaconess Medical Center, **Lianna Schuele**, E'21, industrial engineering, ME'21, engineering management, analyzed the everyday patient experience at the hospital and recommended improvements. "I studied numerical metrics like patient wait times, conducted interviews with key stakeholders and mapped out processes to identify areas of improvement," she says. When the COVID-19 pandemic emerged unexpectedly, Schuele was also able to help the hospital redefine some of its screening and visitation policies, as well as effectively manage the distribution of personal protective equipment (PPE). "In every industry, there are opportunities to examine the way things are done and make workflows run more smoothly. I'd love to have a career in process improvement, perhaps in a manufacturing or supply chain environment, where I can achieve cost savings—but also make people happier and more productive," Schuele notes.

photo by Mathew Modoono

While on co-op, electrical and computer engineering students **Walter Reuss**, E'22, and **Jacob Landgrebe**, E'22, worked with Associate Professor **Taskin Padir** to create robotic technology that could assist manufacturing workers and eliminate the need to send face masks for healthcare workers to outside labs for testing. Padir helped Massachusetts General Hospital build a testbed to put their own surgical masks to the test. As part of this, Reuss and Landgrebe helped analyze the specific ways in which surgical masks and gowns undergo testing for medical grade validation. The fabrics used in masks need to pass different standardized tests to verify how easily they burn, and how effective the garment is at shielding the wearer from splashed fluids, such as blood. In the lab, the students set masks on fire, observing how long it took for the material to burn completely. To test for fluid-blocking capacity, they shot the materials with synthetic blood. Those early experiments, Padir says, were instrumental in designing the robotic system he is now building.

photo by Mathew Modoono



William Olson-Sidford, E'22, bioengineering, who works on SARS-CoV-2 research, co-authored a paper with Professor and Chair **Lee Makowski**, bioengineering, on a hypothesis that was recently published in the journal *Viruses*. The paper theorizes that the spike protein found on the surface of the COVID-19 virus may bind to cellular receptors that regulate blood vessels and control the formation of blood clots, which could explain many of the non-respiratory complications of COVID-19. The spike protein is an arm-like apparatus that the virus uses to attach to and enter healthy cells. At the tip of the spike protein rests a string of three amino acids called RGD. RGD can contribute to the formation of blood clots and the growth of new blood vessels when it interacts with cell receptors called integrins. "Other proteins that have RGD are known to cause complications. Our theory is that RGD is making it easier for the virus to bind to things that could cause these blood complications," says Olson-Sidford. Recognizing that coagulation is a major problem has greatly improved the survival rate of people who are severely sick with COVID-19, Makowski says. Uncovering the cause of that coagulation is the next step.

At their co-op at Iterate Labs, data analytics engineering student **Jignesh Jadhav**, ME'20, and computer systems engineering student **Yiqiang Wang**, ME'20, helped develop wearable devices to keep employees physically distanced and to assist with contact tracing. Jadhav's experience as a contact tracer inspired him to figure out a more effective way to track infections. Wang brought the idea to life by building the back-end software. The pager-like beacons alert wearers when they are too close to others. Employees put the beacons on when they arrive at work, and the devices use short-range radio technology, called ultra-wideband, to communicate and record when two devices come in close contact, uploading that data to the cloud. Then, if someone's been diagnosed with COVID-19, the system can map whom that person has been in contact with. Jadhav and Wang wanted to make the beacons easy to use so that companies can get the process up and running quickly. A company just has to set up location-tracking hubs throughout the facility—similar to a Wi-Fi router—and connect the beacons to the hub, a process that takes around 15 minutes.

Anna LeClair, E'23, environmental engineering, was awarded a PEAK Experience Award from Northeastern University's Office of Undergraduate Research and Fellowships. Advised by Assistant Professor **Kelsey Pieper**, LeClair's research project is, "Safely Reopening Buildings After the COVID-19 Shutdown: Investigating Lead Leaching and Corrosion Scales in Drinking Water." The COVID-19 pandemic forced commercial and academic buildings to abruptly close, causing drinking water systems to stagnate. Corrosion scales that form protective layers inside pipes become destabilized during stagnation, causing lead and other metal leaching and rendering drinking water unsafe. LeClair's bench-scale experiment will investigate this poorly understood phenomenon and determine safe reopening procedures after 1-4 weeks of stagnation to prevent harmful lead exposure. She will present the findings at Northeastern's RISE research expo and other conferences. The findings will be used to revise current EPA utility reopening guidelines.

photo by Mathew Modoono

Laura Bilal, E'21, and Meghan Quon, E'22, bioengineering, are founders of KLIP Tech.

From Pitch to Product

FOR LAURA BILAL, E'21, AND MEGHAN QUON, E'22, BIOENGINEERING, their third-place finish in the 2020 Husky Startup Challenge, taking home $1,000 in funding to pursue their venture, was inspired by their own daily habits and needs. The "challenge" is part of the Entrepreneurs Club–Northeastern's venture incubator and start-up pitch competition.

The pair's invention, KLIP Tech, offers an app connected to a rechargeable device that clips onto clothing and can be activated with either one or two clicks in situations where the wearer may be in some form of distress and unable to quickly access their phone. One click sends a message warning of the wearer's situation and location to a list of personalized emergency contacts, uploaded in the app, and two clicks sends a message to law enforcement to prioritize the wearer's safety. The app also contains a community aspect for users to share their stories of harassment anonymously.

"KLIP Tech sparked out of a personal need because we're both runners in Boston. Meghan's on the club running team, I'm on the club basketball team, and so we go for runs often and you kind of hear about stories of people feeling unsafe or about things that have happened in the community," says Bilal.

"Online we've read tons of testimonials and stories of women who've experienced street harassment, both verbal and physical, and it's crazy how few solutions there are out there to make an individual feel safer. It's not something that we should have to deal with," says Quon. "But it's a reality, so we were really inspired to work towards helping women feel a bit safer, including ourselves."

Quon and Bilal cited the amount of time invested, the Startup Challenge's boot camps, and the mentoring of former Startup Challenge winner **Jaison Patel**, E'22, mechanical engineering, as key to their success with KLIP Tech.

After so much positive feedback on KLIP Tech following their third-place finish, Quon and Bilal shifted their focus to developing their physical product through capitalizing on Northeastern's entrepreneurial ecosystem. They received prototype funding through the student club Origin and were selected by Generate as software and hardware clients.

Generate is a student-run product development studio that is part of the Sherman Center for Engineering Entrepreneurship Education. Generate software engineers are working on prototype interfaces and their interaction with APIs, while the hardware engineers are doing mechanical testing, electronic schematics, and comparing the competition. Quon and Bilal have also brought on board a brand designer and are starting business development efforts such as developing a website.

"If you have an idea and you have a passion and want to pursue it, anyone should feel like they can. The Mosaic [entrepreneurship] community at Northeastern is so welcoming, and it helps to get past that mental barrier, which once you do is such a rewarding experience," says Bilal.

Investing to Enhance the Student Experience

Alumni and friends may be surprised at changes made on the Boston campus in recent years from new buildings like the Interdisciplinary Science and Engineering Complex to a pedestrian bridge over the railroad tracks connecting the two ends of campus. The College of Engineering has also been busy renovating. During the past seven years the college has invested $24.5 million, partly from generous donations, to enhance and expand teaching spaces. From new capstone design studios and makerspaces to modern teaching labs and classrooms, efforts have been to enhance the experience of our students.

View a video tour of the College of Engineering.

Snell Engineering Center Classroom

First Year Engineering Learning & Innovation Center

MIE Capstone Design Studio

ECE Capstone Design Studio and Maker Space

NEWEST ACADEMIC PROGRAMS

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coe.northeastern.edu/doublehusky

A Sigh of Relief

photo by Ruby Wallau

Hari Parameswaran, assistant professor, bioengineering

ANY ORGAN IN THE HUMAN BODY that requires constriction—such as the airways or blood vessels—is lined with smooth muscle that aids in its contraction. In asthmatics, the smooth muscle lining the airways undergoes exaggerated constriction in response to a small amount of inhaled irritants making it difficult to breathe. The exact mechanisms that lead to this behavior are unknown, making effective and universal medical treatment difficult.

Assistant Professor of Bioengineering **Hari Parameswaran**, who received a $602K CAREER Award from the National Science Foundation, seeks to understand how the smooth muscle detects inhaled irritants and generates force at the cellular level to develop better treatment for people with asthma.

In the airway, human smooth muscle cells are supported by a complex scaffold of proteins called the extracellular matrix. This extracellular matrix undergoes substantial changes in asthma. Parameswaran's research discovered that when smooth muscle cells from healthy human donors are placed on a synthetic substrate mimicking diseased tissue, even a tiny dose of an irritant molecule is perceived as a high dose and causes an increased contraction response.

However, the most curious finding is that this abnormal reaction doesn't occur in single smooth muscle cells, but only with a group of cells—meaning the cells are somehow communicating and responding to inhaled irritants as a collective.

"When inhaled irritant molecules bind to the smooth muscle, the smooth muscle cells communicate with each other using calcium waves," says Parameswaran. "These calcium waves are frequency modulated—just like those used in radio communications—and, together like a committee, these cells decide the amount of inhaled irritant molecules. This method of sensing inhaled irritants is fundamentally different from what is currently known. It brings up the intriguing possibility that the individual smooth muscle cell might not be at fault in asthma. Instead, the problem might be in how these cells talk to each other in an asthmatic airway."

Parameswaran's research team includes bioengineering students **Suzanne Stasiak**, PhD'22, **Ryan Jamieson**, PhD'23, **Caroline McCormick**, PhD'24, and Northeastern's Professor **Erin Cram** from the Biology department. While they don't fully understand the mechanisms that underlie the cellular communication process yet, they know that it relies heavily on mechanical forces transmitted through the extracellular matrix: When they mimic healthy extracellular matrix in their lab experiments, this hyperreactive communication stops.

Because Parameswaran's research looks at the dynamic events occurring in cells in different environments, traditional histological slides won't give him and his team the information they need. Instead, they plan to use the CAREER grant funding to develop new experimental methods to help them understand real-time mechanical interactions between cells.

Parameswaran's goal for this work is to provide treatment for severe asthmatics for whom the only current option might be a dramatic therapy called bronchial thermoplasty, in which the smooth muscles of the lungs are heated up and thinned out—an often effective but daunting procedure.

"The idea that the extracellular matrix may have a role in regulating smooth muscle cells is new and exciting," says Parameswaran. "If we're able to understand better how the underlying matrix modulates intercellular communication, we may be able to learn more about what drives the disease of asthma and develop methods to target the cause and not the symptoms of this disease."

Abigail Koppes, assistant professor, chemical engineering

Gut Instinct

THERE'S A GROWING AWARENESS of the connection between the human brain and the intestinal tract, but many questions remain. Why do human neurological disorders, such as anxiety, often manifest themselves with irritable bowel syndrome and other conditions? Why do Crohn's disease and other intestinal disorders have broad implications for the nervous system?

Since joining Northeastern faculty in 2014, Assistant Professor **Abigail Koppes**, chemical engineering, has been investigating these topics.

"The human body is incredibly complex, with a nervous system that acts as an 'information highway,' sending signals and triggering reactions," Koppes notes. "Because we don't understand the invisible mechanisms at work, we are unable to intervene in a helpful way. If we can figure out why the brain triggers a certain response in the gut—and vice versa—we can develop better treatments and improve patient outcomes significantly."

Koppes' research focuses on developing new, non-invasive methods of exploring human cellular responses to biological signals in her Advanced Biosystems for Neuroengineering Laboratory. With almost one-third of Americans currently experiencing clinical anxiety or depression—a statistic that is growing rapidly in the wake of the COVID-19 pandemic—her efforts have wide-reaching implications.

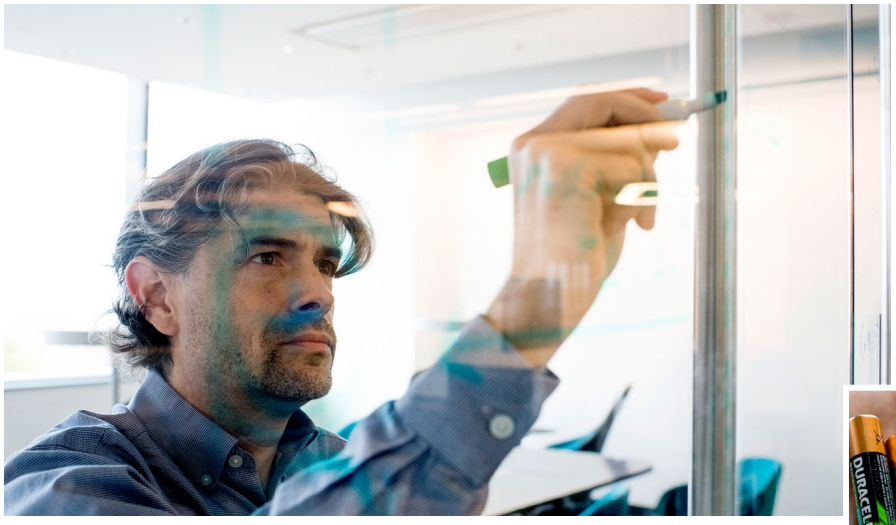
Recently, the National Science Foundation (NSF) granted Koppes a $500K CAREER Award, titled "Defining the Regulators of Enteric Plasticity in Engineered Microfluidic Environments," to further her research. She and her team are developing plastic, disposable handheld devices that expose engineered tissue to a range of signals, then measure its response.

"This new platform will enable researchers to discover ways of turning pathologies 'on and off' via different kinds of biosignals," explains Koppes. "It's a cost- and time-effective means of testing tissue behavior, without risking the health of human or animal subjects. We can easily study reactions at the benchtop, then apply those findings in a clinical setting."

Koppes's lab is partnering with doctors at Massachusetts General Hospital and Boston Children's Hospital, as well as collaborators in Northeastern chemical engineering, bioengineering, and biology faculty. She came to Northeastern as the first ADVANCE Future Faculty Fellow in the College of Engineering in 2013. The fellowship supports translational research that addresses global challenges and enhances social well-being, while also creating a vibrant, diverse community across the university.

"I've been fortunate to be part of an incredibly strong group of women researchers and diverse faculty members," says Koppes. "Engaging in academic research is challenging, but Northeastern has created a real sense of community that makes it much easier and more rewarding."

Making Batteries Safe and Inexpensive for the Electrical Grid



Joshua Gallaway, assistant professor, chemical engineering
photo by Matthew Modoono

FOR THE PAST TEN YEARS, Joshua Gallaway, DiPietro assistant professor of chemical engineering, has been consumed with solving a unique electrochemical puzzle, one that has the potential to make widespread adoption of renewable energy a reality.

Gallaway's work recently earned him a $400K National Science Foundation CAREER Award for "Engineering Electrochemical Reversibility in Disordered Materials for High Energy Density." The award will help Gallaway and his team address the challenge of rechargeability of a battery material, manganese dioxide (MnO_2), that could speed the development of large, low cost, non-flammable batteries capable of powering the electrical grid.

"We've learned that you can make this material, MnO_2, rechargeable by doping it with other atoms," Gallaway explains. "If you use bismuth—a high molecular weight atom—to dope the MnO_2 material, it becomes rechargeable. Then you can conceivably make batteries for the electrical grid that are inexpensive and safe."

Although this phenomenon was originally discovered nearly 40 years ago by a research group at Ford working on an electrical vehicle battery, no one knows why bismuth makes MnO_2 rechargeable. "This is the scientific question that has me most obsessed," says Gallaway.

To figure out this mystery, Gallaway and his team—six graduate students, a post doc and "an army of undergrads"—will make MnO_2 that has several different forms of bismuth doped into it. "The large part is synthesis work with different amounts of bismuth incorporated in different ways," he says. "We are going to characterize that material, where it is and how much of it is there. We'll cycle the material in different ways to see what happens to it and study the relationship between bismuth and the rest of the atoms."

Aiding the team in watching materials while they're doing electrochemistry is a synchrotron, a type of particle accelerator called NSLS-II and located on Long Island. "These facilities make very high-quality X-rays that are also very bright and very high energy," explains Gallaway. "We use powerful X-rays from the synchrotron to focus on bismuth during charging and discharging of the battery to see what the bismuth is doing."

Saving the world

Gallaway is also obsessed with another unique characteristic of the MnO_2/bismuth pairing: while cycling in a battery, the material is initially ordered, showing general regularity, but it becomes disordered, and thus more difficult to characterize. "In the past, we looked at materials from an ordered perspective," he says. "Now we look at these materials from the point of view of disorder, using different X-ray techniques…The point is knowing what bismuth is doing. Then we can engineer it to do better."

Gallaway believes his research, if successful, "could save the world." "If you believe that climate change is real, that it's a problem, then you must stop making electricity with fossil fuels and you need something else," he says. "Solar and wind power is not controllable. Basically, you make electricity when the sun shines and the wind blows. For that reason, when you make electricity, you need to put it somewhere where you can control it, for example, in a battery that stores electricity so you can release it whenever you want. These batteries are uniquely well suited to be in the grid."

Cristian Cassella, assistant professor, electrical and computer engineering

Exchanging Massive Data in Crowded and Noisy Mediums

IN RECENT YEARS, Assistant Professor **Cristian Cassella**, electrical and computer engineering, and his team of PhD students have been developing communication devices that utilize the unique and combined features of electrical and acoustic domains, including components that provide frequency references similar to those used to regulate the motion of a clock.

By leveraging these components, future radios can more easily and more efficiently discriminate data streams from different service bands—such as Bluetooth or Wify—making sure that any received electromagnetic wave reaches the most adequate radio component responsible for extracting the desired information.

"About a year ago, we realized that the technologies used to build passive components in commercial radios were inadequate to keep up with the world's growing communication needs," says Cassella. "This fundamental limitation is even impacting what is attained by emerging computing frameworks—artificial intelligence, machine learning, and edge computing are all growing faster than the hardware can handle, and we needed to produce a jump in technology to keep pace."

Cassella and his team began thinking creatively, which led to a new class of passive, tunable, and high-performance integrated resonant devices called Piezoelectric Resonant Acoustic Metamaterials (pRAMs). pRAMs have unique, artificially produced, and reconfigurable modal features that can be leveraged to form more stable frequency synthesizers as well as to increase the limited resilience to interference of the existing radios.

Well-known in the field of optics, bringing metamaterials into the world of acoustics for communication was a new and needed concept that led to Cassella receiving the prestigious CAREER Award from the National Science Foundation.

"I'm extremely honored," says Cassella. "As a young investigator, this is one of the biggest awards you can get, and I see this as a message that my students and I are clearly looking at a problem that needs to be solved. When an organization like NSF thinks that your work can change the way we interact with each other as well as the quality of any communication links we build, it generates one of the biggest feelings of satisfaction that any academic can achieve."

A member of the College of Engineering since 2018, Cassella obtained his PhD from Carnegie Mellon University, where he studied applied physics and electronics. This overlapping experience allowed him to realize that it is possible to leverage the unique features of one side to overcome fundamental challenges on the other.

As Cassella drives to solve challenging problems in communications, he also hopes pRAMs will enable future generations of connected wireless nodes to be more immune from cyberattacks, while consuming less and less power in favor of longer battery lifetimes. This new technology has ramifications not only in communications, but also in sensing applications where the strong magnetosensitive response of pRAMs will be investigated to form new chip-scale magnetometers with exceptional sensitivities suitable for critical biomagnetic applications and more.

Developing a More Reliable Renewable Energy System

Mahshid Amirabadi, assistant professor, electrical and computer engineering

AN ENERGY SYSTEM IS ONLY AS RELIABLE as its weakest link, which is why **Mahshid Amirabadi**, assistant professor of electrical and computer engineering, has received a $400K CAREER Award from the National Science Foundation to improve the weakest links in renewable energy systems.

"Our main goal is to reduce the cost of electricity from renewable energy," says Amirabadi. "That's what we have to do to make renewables dominant, which is so important to the environment. Additionally, increasing the reliability of renewable energy systems is crucial to building public trust."

Power converters are a key component in transferring power from solar panels and wind turbines into the grid. Amirabadi is developing the next-generation power converter—a universal, silicon-carbide based converter that will be smaller, cheaper and more reliable than those that rely on traditional electrolytic capacitors.

The current converters used in residential solar systems have an average life of 5 to 10 years compared to the 25-year life of solar panels, which means that the overall reliability of the system is cut by more than half. The cost to repair, replace, ship, or install new converters in the system due to this unreliability drives up the overall cost of renewable energy.

Because Amirabadi's converter will be universal it eliminates the need for a series of cascading converters to handle power conversion between sources, and loads with different forms, voltage amplitudes, and frequencies in a complex power system.

"Therefore, the same converter can be used throughout complex systems, as opposed to our current situation where you need many different kinds of converters," she says.

Amirabadi's research builds upon her previous work, including two recent patents: a reliable converter for systems with unequal instantaneous input and output power such as residential solar systems (2019) and a general capacitive-link universal converter that uses soft switching technology to increase efficiency (2020).

She says that several of her proposed converters have been successful in the prototyping process and she is approaching the commercialization stage for those topologies. For now, she hopes to license the inventions through an existing company, and in the future launch a startup of her own.

A Smart Home that Warms the Hearth and Not the Planet

Michael Kane, assistant professor, civil and environmental engineering

IN THE AUTOMATION in the Built and Living Environment (ABLE) Lab at Northeastern, Assistant Professor **Michael Kane**, civil and environmental engineering, and his students look at how people and automation interact in man-made environments such as buildings and transportation. The ABLE Lab's latest project—of which he received a prestigious $763K National Science Foundation CAREER Award—is focused on improving the automation of the home thermostat to not only use less energy, but eventually to anticipate comfort needs.

"The 'brains' of thermostats as we know them today are simple rules that help your home hold a temperature," says Kane. "People don't really know how much energy they're consuming until about a month later when their utility bill arrives, making it hard to know how to save energy. We want to shorten that feedback loop to real-time, and to use human-centric automation to make it something you don't have to worry about."

The science behind Kane's work is to understand all the physiological and psychological factors that affect how people perceive their home's temperature in that moment and change it to make them comfortable. This data could help build artificial intelligence (AI) that predicts how comfortable they are feeling—even before they know it themself—and it helps them understand how to work with AI to make their energy consumption friendlier to an electric grid with variations in available renewable energy.

Kane and his team are partnering with Professor **Misha Pavel** from the Bouvé College of Health Sciences at Northeastern, an expert on health behavior and using smart technology, as well as ecobee, a company that creates smart thermostats and other home technologies.

"Human comfort is a very personal and subjective thing," says Kane. "Sixty-five degrees Fahrenheit in March in Boston feels very different than 65 degrees in August in San Diego. In order to get accurate data, we can't study thermal comfort only in a lab setting."

With the funding from the NSF, Kane seeks to overcome this limitation by recruiting 100 homes across the U.S. for a pilot study. Over a period of several years, they will track their home heating and cooling data with ecobee thermostats. Real-time algorithms will monitor irregular changes in the environment or user behavior and prompt participants to take a second to answer a question with a swipe on their smart watch.

"With this info, we can probe into all of the physical and psychological factors that contribute to a person's comfort" says Kane. "The ultimate goal is to understand these personal internal processes using data from the large cohort of participants to make homes comfortable to the people living there while using energy when the grid is clean and cheap, and holding off on heating and cooling for short periods when the grid is dirty and expensive."

CHANGING THE FACE OF ENGINEERING

photo credit: Giselle Guanes, Instagram account @igguanes

"First-generation engineering students and their parents, especially those from historically underrepresented groups, including African-Americans, women, and Hispanics, are more likely to be unaware of career options in STEM-related fields like engineering," explains **Richard Harris**, assistant dean of Academic Scholarship, Mentoring and Outreach, and director of the Northeastern University Program in Multicultural Engineering (NUPRIME). "Those students who have chosen to pursue degrees in STEM subjects have traditionally found themselves a very small minority, and have often been challenged to find other students who look like them and share their experiences," he says.

Forty years ago, Northeastern's College of Engineering recognized this issue and created Harris' position, previously held by the late David C. Blackman and Paula Leventman, to help minority students acclimate to the College and leverage the many resources available to support them. "The College of Engineering was way ahead of the curve by recognizing that if you really want to encourage diversity, you need to provide formal and informal mentoring, networking opportunities, organizations, and clubs that make underrepresented students feel they're part of a larger community," Harris says.

Rachelle Reisberg, assistant dean of Undergraduate Enrollment and Retention and director of the Women in Engineering program in the College of Engineering, agrees. "In a field typically dominated by men, it's so important that we create a culture where women feel welcome and comfortable. Through the Women in Engineering Program and organizations such as the Society for Women Engineers, our students receive a continuum of formal and informal support from staff, faculty, and peers to encourage them to seize opportunities and help them achieve their personal aspirations."

This formula, combined with offering innovative programs and opening the doors to others, has changed the life of many students over the years. We are proud to shine light on a few of our students, each with unique journeys toward their dreams. While there is much more to do, the success of the college's efforts, from our flagship Summer Bridge program to becoming a National Action Council for Minorities in Engineering partner, is a model for others. Recently, Harris was appointed to the position of special advisor for Educational Pathways Programs in the Office of the Provost to apply his knowledge university-wide.

Richard Harris, assistant dean of Academic Scholarship, Mentoring and Outreach, and director of NUPRIME

Rachelle Reisberg, assistant dean of Undergraduate Enrollment and Retention, and director of the Women in Engineering Program

The 'Triple Husky' Experience

Sarah Brown is a true Northeastern success story: a 'triple Husky' who earned her bachelor's in electrical engineering, E'11, master's in electrical and computer engineering, ME'14, and a doctorate in electrical engineering, PhD'16. After completing her doctorate, she was awarded the University of California at Berkeley Chancellor's Postdoctoral Fellowship and served as a postdoctoral research associate at Brown University. Today, she is an assistant professor of computer science at the University of Rhode Island.

It's clear that Brown's journey to success is the result of talent, drive, and hard work. She was also sustained by an academic environment that both nurtured and challenged her. Supported by a strong network of mentors and advisors, she sought opportunities in and out of the classroom that helped her grow and thrive.

Before she even stepped into her first class, Brown participated in Northeastern's Summer Bridge program. Designed for underrepresented students in engineering, the program extends the regular two-day orientation to a full week during which incoming students get a preview of freshman year coursework, gain valuable exposure to employers in the engineering industry, and connect with other incoming freshmen and upperclassmen.

"You build a cohort of other underrepresented students," says Brown. "That's who my first study groups were with. They were my closest friends all through undergraduate years."

During the program, Brown first learned about the summer Research Experience for Undergraduates (REU) and the Gordon Center for Subsurface Sensing and Imaging Systems (CenSSIS), both of which she participated in as an undergraduate. "It's how I got started in research, which led to my co-ops and to eventually becoming a professor," she says.

Brown credits her co-op experiences with helping her figure out what she wanted to do. "That's how I decided I really liked research, and I ended up doing research for all three of my co-ops," she says. It was while she was at her third co-op at Draper Laboratory that she decided to pursue a doctorate. "All the people that had roles on projects I was interested in had PhDs," she says. "Getting the PhD was the right way."

Brown learned invaluable leadership skills through her involvement with student organizations, most notably Northeastern's Black Engineering

"With the Summer Bridge program, you build a cohort of other underrepresented students. That's who my first study groups were with. They were my closest friends all through undergraduate years."

Sarah Brown
PhD'16, electrical engineering

"[Professor Rappaport] was the first person who ever said to me, 'I think you want to be a professor.' I didn't believe him, but he was right. He gave me the idea … it was important to my trajectory."

Sarah Brown
PhD'16, electrical engineering

Student Society (BESS), a chapter of the National Society of Black Engineers (NSBE). She assumed several senior positions in NSBE's national organization, including National Technical Outreach Community Help Chair and Academic Excellence Chair.

"When I took national leadership positions, I was very well prepared by my BESS experience," she says, noting that because of her involvement with BESS, she felt confident serving in a position on the board that oversaw the entire nonprofit organization—a $10 million budget and 30 staff members. She also learned key skills that would serve her well in her career: grant writing and learning to ask the right questions.

During Brown's 10 years at Northeastern, she says the mentors who guided her along the way had a profound influence on her role as a teacher and advisor today. She recalls working in the lab of her undergraduate research advisor, Professor **Carey Rappaport**, during the first summer after freshman year. "He was the first person who ever said to me, 'I think you want to be a professor.' I didn't believe him, but he was right. He gave me the idea … it was important to my trajectory."

When it came time to find a PhD advisor, Brown chose Professor **Jennifer Dy** who provided the support she needed to complete her PhD, while also making sure she took ownership of her projects. "It was a good balance of pressure to get things done and freedom to really choose what I wanted to do and determine my own course," says Brown. "Her care and thoughtfulness in how she was training us are things I'll continue to do with my students."

Perhaps the most significant source of support for Brown came from the Summer Bridge program and its directors **Richard Harris**, assistant dean for Academic Scholarship, Mentoring and Outreach and director of NUPRIME, and **Rachelle Reisberg**, assistant dean, Engineering Enrollment and Retention & director of the Women in Engineering Program. "He and Rachelle were always there," she says. "Whatever was going on, that was the place I would go for whatever I needed."

In her current position as an assistant professor, Brown teaches data science along with graduate courses on machine learning and society. Her research efforts focus on thinking about and measuring the concept of fairness in machine learning. "I'm collaborating with social scientists on applied data science projects," she says. "I help them analyze data—how they measure and consider evidence of discrimination—and build tools to help them understand and monitor bias." The goal, she says, is to determine how to minimize these biases, particularly gender and racial bias, and prevent them from affecting people down the line.

As she looks ahead to the future, Brown is focused on earning tenure and continuing to build up her interdisciplinary and applied research. She is also committed to encouraging students like herself. "I care about student development and improving retention and diversity efforts," she says.

photo credit: Giselle Guanes, Instagram account @igguanes

"Northeastern was very good to me. I had a combination of a great group of friends—a few of whom have become family to me—and a series of good mentors."

David Delaine
E'05, electrical engineering

The Perfect Detour

Northeastern graduate **David Delaine**, E'05, electrical engineering, was well on his way to a solid career as a consulting engineer, but life had other plans for him. A network of mentors and transformative experiences at Northeastern and beyond laid the groundwork for a career detour that led Delaine to pursue advanced studies and discover his passion for engineering education. Today he shares that passion with the next generation of STEM students as an assistant professor in the Department of Engineering Education at Ohio State University.

Born in Queens, New York, to immigrant parents from Martinique and Costa Rica, Delaine spoke several languages and developed a lifelong love of travel and culture, inspired by visits to his parents' birthplaces. A move to Westchester, an experience that Delaine—who identifies as Black and Latino—found "culturally difficult," gave him an innate understanding of how race and culture were manifested in the world and ultimately played a role in his career choice.

Accepted at several colleges, Delaine chose Northeastern where he was awarded the Ralph J. Bunche scholarship. His decision to study electrical engineering was, in Delaine's words, "logical." "All I knew is engineers make good money. I had no idea what it was. I chose it because I was told it was a good career."

Describing his undergraduate experience, Delaine says, "Northeastern was very good to me. I had a combination of a great group of friends—a few of whom have become family to me—and a series of good mentors."

Delaine recalls two successful co-ops, one with the Harvard University Engineering and Utilities Group led to what he assumed would be his career following graduation. He worked on power distribution with an influential mentor, Michael J. Rossini, who helped him parlay his experience into a job at an engineering firm in New York City. "I was all set to continue working beyond graduation until [Assistant Dean] **Richard Harris** threw a wrench in the story," says Delaine.

Prior to graduation, Delaine decided to attend the National Society of Black Engineers (NSBE) convention. Richard Harris, assistant dean of Academic Scholarship, Mentoring and Outreach, and director of NUPRIME, pushed Delaine to go to the NSBE graduate school fair. Delaine had no intention of going to grad school or the fair, but Harris was persistent.

At the fair, Delaine learned about the National Science Foundation LSAMP Bridge to Doctorate program. Intrigued, he decided to apply, secured the fellowship, and left his New York job behind, ultimately earning a PhD in electrical engineering from Drexel University in 2012. He also followed his PhD up with the prestigious Fulbright scholarship and post-doctoral research in Brazil.

While at Drexel, Delaine got involved with supportive organizations. "It's how I fell in love with engineering education," he says. "It's about how you prepare engineers to do the work they're doing in meaningful ways in the world we're living in."

In his current role as assistant professor, Delaine directs the Inclusive Community Based Learning Lab (iCBL) whose mission is to support the development of socially responsible engineering professionals through service learning, volunteerism, and outreach, and broaden participation in engineering and STEM. Reciprocal partnership and community impact are cornerstones of the research.

"This form of teaching can also promote on a small and local scale social change, and have a positive impact on social justice," he says.

Contributing to a Positive Vibe for Everyone

"I don't know why, but from a young age I've always loved chemistry," says **Lineyah Mitchell**, E'21 and ME'21, chemical engineering. While she considered Ivy League universities, she wanted to go someplace where she could really focus on technical studies. Then she visited Northeastern.

"I really liked the vibe when I visited," Mitchell explains. "People didn't look miserable! Other campuses I visited weren't as lively or welcoming." Add that positive vibe to the University's co-op program, and Mitchell's mind was made up.

Mitchell completed co-ops with Concert Pharmaceuticals and Via Separations, and got wide-ranging experience to help her narrow down her interests. At Concert Pharmaceuticals she was on the Pharmaceutical Development team and responsible for process development and data analysis, while at Via Separations she produced and tested membranes and membrane elements in tandem with scale-up efforts and was responsible for data analysis.

During her time at Northeastern, Mitchell has done more than most to help continue—and broaden—the welcoming, lively atmosphere she fell in love with during her campus visit. She has worked tirelessly to help make engineering careers more open and inclusive for everyone.

She was on the executive board of the Black Engineering Student Society (BESS) for three years. "One small thing anyone can do to help make sure everyone feels welcome is simply have a conversation," she explains. "If you see someone sitting alone, go talk to them, listen to them."

For all her accomplishments at Northeastern, Mitchell has earned the National Action Council for Minorities in Engineering (NACME) scholarship. NACME is the largest provider of college scholarships for underrepresented students pursuing degrees at schools of engineering. Northeastern is the only university partner in Massachusetts out of 38 university members nationwide.

What Mitchell really appreciates about the scholarship is the networking opportunities and events the organization develops. "Nobody knows every option in their field, so you can learn so much just from the networking opportunities," she describes. "You can learn new information about your field, your career, yourself, and also other fields."

She also appreciates that the organization clearly considers and plans events carefully. For example, for a virtual career fair, students weren't just given a link and left on their own. They were given guidelines to go to three sessions and talk to at least 10 people. "So, even now, they're helping introduce us to companies that want to hire NACME scholars and are hiring full-time for co-ops," she describes.

After graduation, Mitchell plans to work in industry and then perhaps head back to school for a PhD, or other advanced degree, after a few years.

The Power of Community

Originally from Colombia, **Juan Mesa**, E'21, mechanical engineering, grew up in Boston and always had a love for cars. That love steered him to MassBay Community College where he received a degree in Automotive Technology. However, he knew he needed something more. He applied to Northeastern and joined the College of Engineering through the S-POWER scholars program.

Standing for Student Pathways Opening World Energy Resources, S-POWER aims to increase workforce diversity in STEM fields and the energy sector. Funded with a $5 million, five-year grant from the National Science Foundation, the program is centered around providing students prior to as well as during their time at Northeastern with research, mentoring, career development, and education preparation. For Mesa, it helped him find a true community and gave him the opportunity to become the best version of himself.

With two successful co-ops under his belt—Nova Biomedical and Waters Corporation—Mesa explains that he's always had the initiative to work hard. In both of those experiences, he says it was important to remember that he did not know everything, but that was why he was there.

"You're there to learn," Mesa says. "Writing up a presentation may not have been my strongest asset, for example, but it was about taking the time to do something good. All of those little things add up throughout time and can have a big impact on my life and other people's lives as well."

At Nova Biomedical, Mesa helped to develop over 15 test fixtures of varying complexity using SolidWorks to support the manufacturing process of the analyzers. He also designed a Cell Density Viability Module from start to end and wrote and edited over 10 assembly and test procedures. At Waters Corporation he tested and diagnosed mechanisms using self-made optical test bench and MATLAB. Additionally, Mesa designed and developed next-generation appliances using SolidWorks.

"I am determined to accomplish a lot of things," he says, adding that he wants to make a positive impact in the world. "I want to have a venture focused on bringing energy to developing countries or those that have little to no resources," he says. "For example, places in [Colombia] have no access to clean water, and in this day and age, these issues are unacceptable. Here, the exceptional education I have received has given me the resources and knowledge to build something for those in need."

Spurred from an initiative to foster climate change and global inequality awareness, Mesa recently started a venture called Mesa & Co, an e-commerce platform that sells sustainable and ethically sourced goods from small businesses in the U.S. and artisans in developing and developed countries around the globe. Awarded a GEM Fellowship, Mesa will be attending Carnegie Mellon University to do a PhD on advanced hydrogen energy systems.

"Here, the exceptional education I have received has given me the resources and knowledge to build something for those in need."

Juan Mesa
E'21, mechanical engineering

"I think what helped me stand out [for graduate school] was the additional experience that I had with undergrad research, co-op, and being active in [student] organizations."

Elisa Livingston
E'14, civil engineering

Coming Full Circle

"Originally, I'm from Colombia, and I immigrated with my mom to the U.S. when I was eight," says **Elisa Livingston**, E'14, civil engineering. Livingston's mother worked multiple jobs so that Elisa could have the best educational opportunities. "My mom, she sacrificed so much." Northeastern offered the career-focused engineering programs that Livingston was looking for—especially with its co-op.

Initially, Livingston wanted to pursue a career in construction, but after her first two co-ops she reconsidered. For her third co-op, she worked in the structural engineering department at Simpson Gumpertz & Heger. "This last co-op cemented the fact that this is what I wanted to do and also made me realize that I needed to go to grad school if I wanted to pursue that discipline," she says.

Fortunately, Livingston had built a substantial CV at Northeastern. "A lot of things just aligned. I started doing undergrad research. I started to publish. I started to present papers in different conferences and really build up my resume."

She also grew in other ways. In 2013, Livingston and a dozen other students flew to Cameroon in Africa for forty days for a Dialogue of Civilizations, led by **Richard Harris**, assistant dean of Academic Scholarship, Mentoring and Outreach, and director of NUPRIME. "The Cameroon Dialogue was probably my favorite experience at Northeastern," Livingston says. Northeastern students collaborated with local students in the town of Bali to propose solutions to common problems faced by residents.

Livingston's workgroup sought to reduce food waste in Bali. In this town, farmers gather to sell their produce in the marketplace once a week. Many of the farmers grow the same crops, so there is often a higher supply than demand of the crops. As a result, the products that don't sell that day must be discarded. Livingston and her group proposed that plantain farmers convert some of their crops into plantain chips, "a product that is more sustainable, lasts longer, and diversifies the market," she explains. Livingston believes that this project reshaped her approach to engineering.

"The collaborative aspect of working with students with other backgrounds helps me to this day. As a structural engineer, I'm constantly working with different teams, different architects," Livingston says. "I was really learning how to collaborate efficiently, how to take other people's ideas and implement them into a bigger idea; and attacking problems, synthesizing them in ways that you can see them from different viewpoints and break them down into different pieces; learning how to communicate with people from different backgrounds and maybe who aren't fluent in English; being thankful for the day-to-day things that we have access to. Not everyone has access to education or running water or electricity or food."

With Northeastern's student clubs, Livingston also developed leadership skills—serving as a board member of the Northeastern chapters of both the Society of Hispanic Professional Engineers (SHPE) and the American Society of Civil Engineers (ASCE). "I think what helped me stand out [for graduate school] was the additional experience that I had with undergrad research, co-op, and being active in these organizations," Livingston reflects.

Livingston went on to earn her Master of Science in Structural Engineering at University of California Berkeley in 2015. She has had a successful career as a project consultant in structural engineering for the past five-plus years at Simpson Gumpertz & Heger—where she had her third co-op years ago.

A World of Difference

While growing up in South Florida, **Diego Rivera**, E'21, was always drawn to science and math. But it wasn't until he took a physics class in high school that he began to see a clear career path for himself. "It was the first time I realized that science had practical applications. That's when I began to think about an engineering career," says Rivera.

At Northeastern, Rivera quickly gravitated toward a major in mechanical engineering, including courses in materials science. "Mechanical engineering manifests a lot of physics concepts and it involves experimentation, which I've always enjoyed," he explains.

In two co-ops—with startups Form Energy and Via Separations—Rivera studied ways to improve manufacturing processes, including materials-related tasks such as coating and annealing. He learned that materials choices not only impact product failure rates and durability, but they also affect the environment. Always passionate about the environment, Rivera realized his own career could have a positive impact on the world's ecosystems.

"I've had an awareness of climate change my entire life," notes Rivera, "but the prospect of global warming seemed abstract, daunting, and scary. In working for these startups, I discovered there's a whole community of people who are driven to combat climate change. And I want to be part of that community."

A critical aspect of Rivera's time at Northeastern has been his involvement in the Society of Hispanic Professional Engineers (SHPE). "I moved here from Florida and didn't know anyone," he recalls. "While touring the campus, I saw the SHPE booth and immediately felt at home. It's a tangible group of people who share similar experiences and support each other. My membership in SHPE is an integral part of my experience at Northeastern." In his second year Rivera served as SHPE's community outreach chair, and the next year he was elected president.

Rivera also took a leadership role in Northeastern's Alternative Spring Break (ASB) program, an annual week-long service project where students perform hands-on work to support housing security, food security, LGBTQ+ advocacy, healthcare access, and other social issues. Rivera planned trips and recruited volunteers.

"My time at Northeastern has demonstrated the importance of belonging to a community and giving back to that community," he emphasizes. "No matter where my career takes me, I'll always try to integrate community service into it. I want to help improve the world in both my professional and personal life."

Ultimately, Rivera sees himself working as a senior scientist doing experimental work that supports environmental sustainability. This summer, he'll intern at the National Renewable Energy Lab in Colorado, an opportunity he pursued through the National GEM Consortium. A recipient of a National Science Foundation Graduate Research Fellowship, in the fall Rivera will enroll at Stanford University in a PhD program in materials science.

"I saw the SHPE booth and immediately felt at home. My membership in SHPE is an integral part of my experience at Northeastern."

Diego Rivera
E'21, mechanical engineering

Eno Ebong, associate professor, chemical engineering and bioengineering, and Solomon Mensah, PhD'19, bioengineering

It Started with a Mentor

After earning his bachelor's degree at City College of New York, **Solomon Mensah**, PhD'19, bioengineering, chose to further his education at Northeastern for its entrepreneurial atmosphere, and to study under his undergraduate mentor who joined Northeastern, Associate Professor **Eno Ebong**, chemical engineering and bioengineering.

Mensah's graduate research, supervised by Ebong, examined inter-cellular interactions in cancer and cardiovascular diseases and the role played by the blood vessel wall sugar coating "glycocalyx." This analysis aimed at improving cancer and cardiovascular treatment earned Mensah the prestigious National Science Foundation Graduate Research Fellowship Award.

While studying and researching at Northeastern, Mensah founded Therapeutic Innovations in 2014, a company that redesigns medical devices so that they are less expensive and easier to use for developing countries. The company's goal is to improve children's quality of life by providing them with affordable life-saving devices.

On a trip to Ghana, Mensah learned that respiratory problems among newborns, particularly premature babies, are common, but equipment to help them was scarce. Having grown up poor in Ghana, he was driven to help others like him—using the knowledge, engineering skills, and entrepreneurial spirit he gained at Northeastern. "I realized I could do something about this," he says.

IDEA, Northeastern's student-led venture accelerator, provided Therapeutic Innovations with gap funding for a bubble continuous positive airway pressure (CPAP) machine for neonatal infants with respiratory distress syndrome in Africa and India. He also connected with Boston-area mentors through the university's Health Sciences Entrepreneurs program and partnered with the College of Engineering's student-led product development studio Generate to test technical aspects of the product. The project proved to be a massive success.

Mensah received a $50,000 National Science Foundation grant as part of its I-CORPS program for his CPAP project in 2017. He was also a finalist in the 2016 MassChallenge. In 2018, Mensah was selected to present his pitch, "Re-Examining the Design of the Neonatal Bubble-CPAP for Application in the Developing World," at the 15th annual Global Health & Innovation Conference at Yale University. This convention gathers more than 2,000 leaders and innovators in social entrepreneurship and global health from around the world to pitch their ambitious projects.

Now, Mensah is a new father, and an assistant professor at Worcester Polytechnic Institute in the Department of Biomedical Engineering. One of his graduate classes is titled "Medical Device Design for Global Health." The publication *Cell Mentor* has named Mensah and Ebong among 1000 inspiring Black scientists in America. ■

Engaging Research from the Start

Curiosity and engagement are top traits of high-potential talented students. To tap into and nurture this excitement, the College of Engineering introduced an innovative program in Fall 2020: Undergraduate Program for Leaders In Future Transformation (UPLIFT).

UPLIFT Scholars are paired with a faculty mentor and work in their mentor's lab conducting research starting their first semester of their first year of study at Northeastern. By targeting research in the fall, a directed study (general elective) in the spring, a Research Experiences for Undergraduates in the summer, and additional experiences thereafter, scholars become competitively positioned for graduate work, national scholarships, and other accolades. Scholars also receive programming and community building opportunities through Northeastern's Center for STEM Education.

With faculty mentor Professor **Jeffrey Ruberti**, **Jordan Stewart**, E'25, bioengineering, is engaged in research to create more efficient and cheaper COVID testing methods. "I'm doing a directed study this semester, and I only got that because of this program," says Stewart who is testing whether certain kinds of microbes can be manipulated to signal a positive COVID test.

Stewart, who also participated in the Summer Bridge program and is a National Action Council for Minorities in Engineering (NACME) scholar, says "I think that the program will help me a lot with my co-op applications and give me a leg up."

Daniel Devory, E'25, electrical and computer engineering, is researching how to speed up wireless communications systems as part of the program. Working under the guidance of Associate Professor **Josep Jornet**, Devory is helping to design an antenna that can propagate high-speed connections. Jornet is the director of the Ultra-broadband Nanonetworking (UN) Laboratory, which performs research on terahertz communication networks, wireless nano-bio-communication networks, and the Internet of Nano-Things.

"For wireless communications, all you want is really fast speeds and reliable connections," says Devory. "Right now you'll see 2.4 and 5 GHz. The lower GHz range is what most wireless electronics are using. But for faster speeds, you're looking for a higher bandwidth. Since so many things are on this bandwidth in the low GHz, we had to find something that we could actually use to get to the higher speeds. That happens to be the terahertz band because nothing is really using it," he explains.

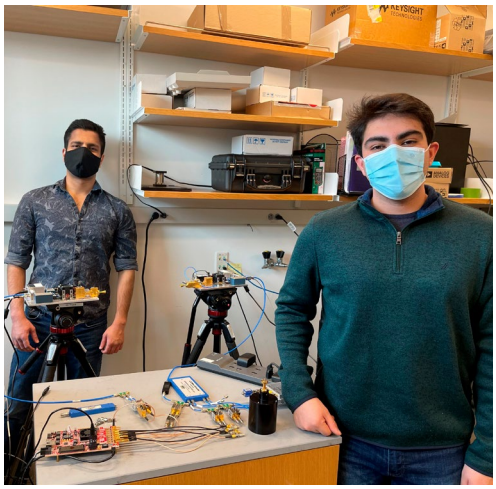
Jornet and **Arjun Singh**, PhD'24, electrical engineering, taught Devory how to use the multi-physics simulation COMSOL and the Discover supercomputer to test potential antenna designs. "Even with the use of powerful hardware, different testing methods are needed to reach our research goals. Research is about discovering new things and attempting to overcome the obstacles that arise," Devory says.

Devory's research ultimately earned him a $500 PEAK Experiences Base Camp Award from Northeastern University's Office of Undergraduate Research and Fellowships. Devory says that he and his team will use the money to have his antenna design manufactured.

"The UN Laboratory has one of the only test beds that can actually test terahertz frequencies. So once we get it made, we can actually test it," he says.

Another Summer Bridge participant and talented UPLIFT scholar is **Sofia Hadwen**, E'25, environmental engineering. She is studying the effects of plastics on the environment with Associate Professor **Aron Stubbins**. More specifically, Stubbins' research investigates how the sun degrades different types of plastics and what role microplastics play in microbial ocean life.

"I don't think I would have gotten into research my first year, let alone my first semester, if it weren't for the program," Hadwen says.



From right: Daniel Devory, E'25, electrical and computer engineering, works with Arjun Singh, PhD'24, electrical engineering, in the Ultra broadband Nanonetworking (UN) Laboratory.

Just What the Doctor Ordered

Human beings are some of the most complex systems in the world, and responses to illness, disease, and impairments manifest in countless different ways. When it comes to making sure that *your* system stays up and running, healthcare professionals typically have their own deep well of knowledge—but the addition of artificial intelligence tools offers unprecedented support from millions of data points, global expert opinions, and the objective conclusions that only machine learning can provide.

Working with Northeastern's newly established Institute for Experiential AI—a $50 million investment forming a research hub of human and artificial intelligence collaboration, as described on page 44—College of Engineering researchers are putting artificial intelligence to work in the healthcare industry and beyond.

photos by Northeastern University Communications

Deniz Erdogmus, professor, electrical and computer engineering

Coming to an understanding

Professor **Deniz Erdogmus**, electrical and computer engineering, is working with experts at Oregon Health & Science University (OHSU) on assisted communication devices for people with speech and/or physical impairments.

The project started in 2009 as a brain/computer interface that allowed users to express themselves using an RSVP Keyboard™, which works by identifying changes in the brain's electrical activity when viewing flashing letters on a computer screen. Erdogmus and his team are combining data from the user's brain signals along with context-specific language models from their conversation partner and other environmental factors.

"We just got our third renewal on our National Institutes of Health grant," says Erdogmus. "In this next five-year phase, we'll be looking at data from eye tracking, muscle activity through electromyography (EMG), and button presses as well. Because each user is different in terms of their neurological conditions and body control, we want to be able to give them options on the best way to use their communication device."

A significant advantage of this multimodal communication system is for people with progressive diseases like amyotrophic lateral sclerosis (ALS), who might have some muscular capabilities earlier in their disease that might disappear with time—but because the device has learned their individual signals, it can still help them communicate with ease.

From the first days of life …

Another OHSU collaboration sees Erdogmus partnering with ophthalmologists on an NIH-funded grant to better identify and treat retinal disease in premature infants.

"When babies are born prematurely, there is frequently a concern about retinopathy of prematurity (ROP), a disease in which the retina is not fully or properly formed yet," says Erdogmus. "If detected and assessed properly, ROP can be treated to prevent vision loss, but outside of urban areas the technology for identifying it isn't as widely available."

With a network of healthcare providers in rural North American and underdeveloped countries such as India and Nepal, Erdogmus and his team are working with retinal images of preemies from specialized cameras. Using a neural network to identify and classify problem signs in the images, the team seeks to create a mobile imaging platform that can be used anywhere to get a better, faster diagnosis of ROP.

The U.S. Food & Drug Administration has granted the team's mobile device technology a Breakthrough Devices classification.

Sarah Ostadabbas, assistant professor, electrical and computer engineering

In another project on early development, Assistant Professor **Sarah Ostadabbas**, electrical and computer engineering, is working with researchers across Northeastern and at the University of Maine using artificial intelligence to examine the interplay between pacifier use and sudden infant death syndrome (SIDS).

"Disruption of motor development in infancy is a risk indicator for a host of developmental delays and disabilities and has a cascading effect on multiple domains: social, cognitive, memory, and both verbal and non-verbal communication," says Ostadabbas. "Despite the clear advantages of early screening, only 29% of children receive some form of developmental testing. Automation of home-based screening tests can increase the percentage of children who are looked at for early delays and atypical development."

While many U.S. families have baby monitors that supply a wealth of visual data about babies' behaviors, physicians don't have the time to observe them for clues. That's where automation comes into play: Ostadabbas is using her expertise in computer vision and advanced AI to create algorithms that can search for and identify sleep posies, facial expressions, and pacifier use behavior poses that can potentially signify developmental delays in infants.

These algorithms, however, are very data-hungry, and there are security and privacy issues that come along with using images and video of infants. In order to work around this "small data" problem, Ostadabbas has developed data-efficient machine learning approaches to enable advanced AI algorithms for this application.

To mitigate the data limitation issue and towards developing a robust infant behavior estimation/tracking system, Ostadabbas' technique has a framework that is bootstrapped on both transfer learning and synthetic data augmentation approaches. First, it makes use of an initial pose estimation model trained on the abundant adult pose data, and then finetunes the model on an augmented dataset consisting of a small amount of real infant poses and a series of synthetic infant videos using simulated avatars.

Because nothing simulated is exactly like real life, Ostadabbas has also developed a context invariant representation learning algorithm that helps narrow the data distribution gap between the infant avatars and real infants' appearances.

"The specific application here is on a project about infant behavior monitoring, but the concept of small data problems runs throughout many domains, including much of healthcare and the military," says Ostadabbas. "Besides AI models that we create, we are also making several publicly available datasets in small data domains; everyone needs more data, and we want to help advance the science."

The National Science Foundation has funded the collection of some of Ostadabbas' datasets related to sleep pose estimation studies.

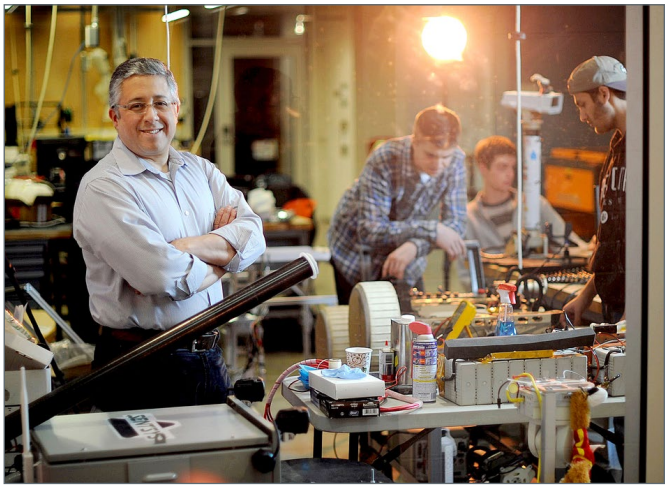


photo by Mathew Modoono

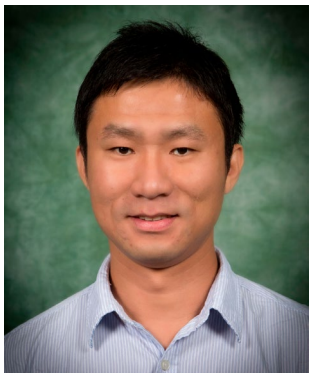
Taskin Padir, associate professor, electrical and computer engineering

... to the Golden Years

Associate Professor **Taskin Padir**, electrical and computer engineering, has embarked on a new collaboration with researchers from Japan on developing technology for healthy aging and longevity in the home in adult populations. In both countries, older adults are living longer and more active lives, which will necessitate new technology to help them stay healthy and independent.

"Both qualitative and quantitative data showed us that the global pandemic had dire consequences on older populations," says Padir. "We need to provide meaningful technology to keep them engaged and empowered, but that also has the capability to care for them."

In a time when taking a taxi or a Lyft to get to the grocery store isn't an option, Padir and his collaborators are seeking use-inspired and data-driven approaches to provide safe



"By using automation, we can provide personalized guidance for the medical provider in identifying real-time responses."

Chun-An (Joe) Chou
assistant professor, mechanical and industrial engineering

mobility between home and everyday destinations and can be used by family to check up on elderly relatives.

"We are really going back to the drawing board with what this future mobility device could look like," explains Padir. "It's not a wheelchair or a Segway, but what is in between? Is it foldable or shape-changing so I can both sit or stand on it? Is it indoor/outdoor? Can it help me with my cooking or cleaning? The possibilities are endless."

From point A to point B

Another of Padir's projects seeks to create an assisted mobility system for individuals with disabilities. His research focuses on bridging the technological gap between getting the robot to understand human intent, preferences, and expectations and accomplishing the correlating tasks with the machine's capabilities.

"For more than a decade we've been looking at utilizing robots for health applications—not only in homes and hospitals, but also in common spaces," says Padir. "This can't be achieved just by algorithms, so we're relying more on human feedback and giving a person adaptive use of the technology; not one solution will fix all needs, and not the same solution will fit the same person all the time."

Padir's vision for his assisted mobility technology ranges from a traditional wheelchair with a joystick to a self-driving wheelchair that takes in some level of human input, such as gestures or brain signals, to make sense out of the user's intent. Padir and his team have gotten feedback from more than 250 users so far to understand their day-to-day activities and challenges, such as navigating a subway station during rush hour, or traveling on the sidewalk without running into people.

"We've often heard that the first mile and the last mile are the hardest for people with disabilities trying to make their way from place to place," says Padir. "Once you're on the subway, or the train, or the airplane, things are relatively easy—but the challenge is getting there and back."

Padir's human-robot interaction project has been through some in-home environment trials, but he now seeks to take the show on the road. His vision is to help a resident of The Boston Home, an assisted living facility in Dorchester, Massachusetts, to the Boston Symphony Orchestra and back using MBTA transit and the independent mobility provided by the robotic device.

Offering more comprehensive care

Assistant Professor **Chun-An (Joe) Chou**, mechanical and industrial engineering, is using machine learning techniques to help provide objective feedback to medical professionals on sensory or motor impairments in patients after strokes to improve rehabilitation.

In collaboration with the The Stroke Center at Tufts Medical Center, Chou—with Professor **Yingzi Lin** and Associate Clinical Professor **Sheng-Che Yen**—has developed a virtual reality driving simulator to test patients' response behaviors and timing.

Chou's research focuses on people about 2–6 months after a mild stroke who have moderate impairments. Their hypothesis is that by better identifying their issues, they can help people return to normal life activities more quickly.

"By using automation, we can provide personalized guidance for the medical provider in identifying real-time responses," says Chou. "From a delay in noticing a pedestrian crossing the street to not seeing a stop sign, the patient's cognitive responses can be categorized using artificial intelligence to offer providers a window into their impairments and recovery."

This AI-based assessment tool can be generalized to other diseases/disorders causing relevant impairments or disabilities.

Chou has been awarded a Tufts CTSI Pilot Studies Program grant as the principal investigator of this project.

Monitoring patient behavior

Another Northeastern researcher seeking to augment patient care is Professor **Raymond Fu**, electrical and computer engineering. He is putting his experience using low-cost and portable sensors to work in digital healthcare by monitoring patient behavior during rehabilitation and exercise to increase effectiveness and decrease injury.

Using artificial intelligence to analyze data from sources like muscle sensors, 3D motion capture sensors, camera sensors, and more, Fu seeks to teach the AI system to generate alerts about anomalies or suggest additional services to facilitate researchers, therapists, and doctors in their practice.

"In physical therapy or rehab, patients want to follow their therapist's practice on their own," says Fu. "By teaching AI to perform recognition, classification, tracking, and analysis—all remotely, quickly, and highly efficiently—we can help health practitioners offer instantaneous feedback and support."

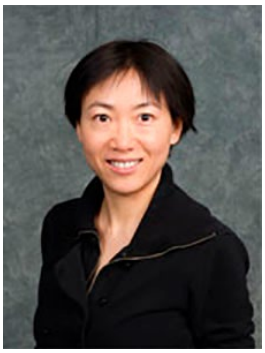
Fu has been working on this research since 2012 and advancing technology has allowed him to utilize more advanced tools, including camera data from patients' phones, laptops, or tablets; more lightweight sensor technology; and the surge of interest in remote health applications—especially in the wake of a global pandemic.

"The evolution of technology in the human activity recognition field over the last decade has gone from expensive to cheap, and from relatively weak to incredibly powerful," says Fu. "It allows the integration of neural networks and machine learning to be more feasible and run in real time, and users can be very decentralized from the cloud. So much research was just sitting in the lab and not being applied because the speed and the infrastructure just weren't there to support it—but now they are."

photo by Mathew Modoono

"The evolution of technology in the human activity recognition field over the last decade has gone from expensive to cheap, and from relatively weak to incredibly powerful."

Raymond Fu
professor, electrical and computer engineering



"This advanced sensor technology combining with interpretable AI can ensure that we produce high-quality bio-drugs and vaccines quickly and safely."

Wei Xie
assistant professor, mechanical and industrial engineering

Protecting life-saving medicines

The biopharma industry is growing rapidly and is increasingly able to cure severe health conditions, such as many forms of cancer and adult blindness. However, drug shortages have occurred at unprecedented rates over the past decade, especially during the COVID-19 pandemic.

Assistant Professor **Wei Xie**, mechanical and industrial engineering, is working with partners in both academia and industry to develop risk-based interpretable artificial intelligence to accelerate end-to-end biopharmaceutical manufacturing innovations and improve production capabilities.

Protein drug substances are manufactured in living cells, whose biological processes are complex and have highly variable outputs depending on complex dynamic interactions of many factors, such as intracellular gene expression, cellular metabolic regulatory networks, and critical process parameters. In addition, the biomanufacturing production process usually includes multiple steps, from cell culture to purification to formulation. As new biotherapeutics (e.g., cell and gene therapies) become more and more ``personalized," biomanufacturing requires more advanced manufacturing protocols. Thus, the productivity and drug quality are impacted by the complex dynamic interactions of hundreds of factors.

"If anything along the biopharma manufacturing isn't exactly right, the structure of the protein can become different, which directly impacts drug functions and safety," says Xie. Further, the analytical testing time required by biopharmaceuticals of complex molecular structure is lengthy, and the process observations are relatively limited.

To maximize productivity and ensure drug quality as measured by FDA-required standards, Xie's research team is employing risk management, process optimization, and interpretable AI. Through collaborating with Physical Sciences Inc. and UMass Lowell, we can monitor in real-time the critical variables, from the metabolic health of each individual cell to the entire manufacturing process.

"Our risk-based interpretable AI approach can advance the deep scientific understanding of biological/physical/chemical mechanisms for protein synthesis at molecular, cellular, and system levels, support the real-time release, and accelerate design and control of biopharmaceutical manufacturing processes," says Xie. "This study can proactively identify and eliminate bottlenecks and anomalies, accelerate production process development, and improve production capabilities and sustainability."

Xie has recently completed a research proposal for the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) with Northeastern's Biopharmaceutical Analysis Training Lab (BATL), MIT, Sartorius, Genentech, Centuria, Janssen, and Merck that seeks to bring this AI technology to market and support the biomanufacturing workforce innovations.

"This advanced sensor technology combining with interpretable AI can ensure that we produce high-quality bio-drugs and vaccines quickly and safely," says Xie.

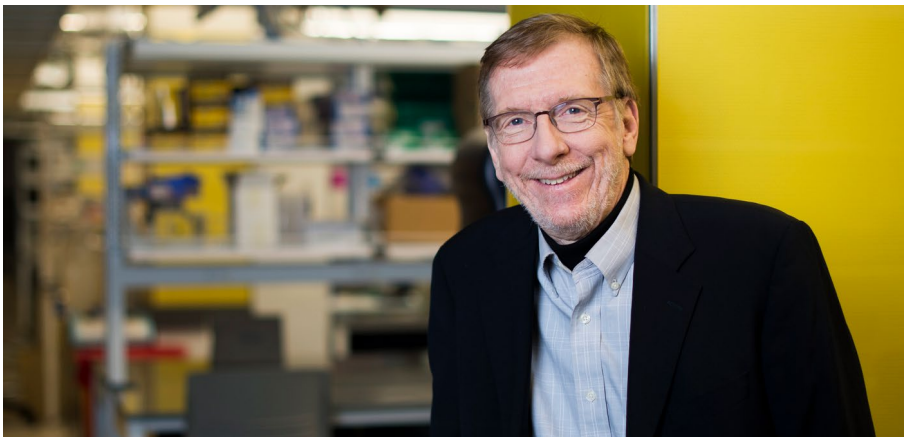


photo by Adam Glanzman

Understanding Alzheimer's progression

Professor and Chair **Lee Makowski**, bioengineering, aims to understand the molecular basis for the progression of Alzheimer's disease by shooting X-rays at thin histological sections of human brain tissue to collect and examine data on the structure of lesions.

"Alzheimer's is perplexing because it works so slowly, over a period of years, even decades," says Makowski. "An even bigger issue is that the molecular lesions (known as amyloid plaques) don't correlate well to the disease's symptomology: Someone who has deep dementia may not have many lesions in their brain, and someone with many lesions may not suffer dementia. We're trying to find out why that is."

One of theories Makowski and his team are investigating is that there are different types of amyloid plaques, with some being neurotoxic and others benign. Using artificial intelligence algorithms to evaluate the histological images, they hope to learn how to tell the difference at the molecular level so that doctors can eventually focus therapies on the lesions that are most dangerous.

Interestingly, some of the algorithms that Makowski is using have been around for a long time—but it's only because of the advent of higher computing power and data storage in recent years that make them more useful.

"The data we're collecting is modest by Big Data standards, but 10 years ago couldn't have afforded the disk space to store it—now you can purchase enough storage at Best Buy to last us years," says Makowski. "The availability of data storage and more powerful computational platforms have been game changers in terms of our ability to use artificial intelligence to investigate these issues. The next five years in bioengineering are going to be incredibly productive because of new resources."

"Alzheimer's is perplexing because it works so slowly, over a period of years, even decades. An even bigger issue is that the molecular lesions (known as amyloid plaques) don't correlate well to the disease's symptomology."

Lee Makowski
professor and chair, bioengineering

photo by Ruby Wallau

"We want to determine what are the molecular variations that make macrophages act differently so that we can potentially convert one type to another to increase the body's effectiveness at fighting cancer from within."

Nikolai Slavov
assistant professor, bioengineering

Predicting molecular mechanisms of disease

Assistant Professor **Nikolai Slavov**, bioengineering, is using AI and machine learning to predict molecular mechanisms of disease through protein analysis of thousands of single cells. Slavov is currently interested in examining how diseases such as cancers and autoimmune disorders interact with human macrophages, a type of immune cells.

"When macrophages come in contact with cancer cells, they can either attract and kill them or protect them," explains Slavov. "We want to determine what are the molecular variations that make macrophages act differently so that we can potentially convert one type to another to increase the body's effectiveness at fighting cancer from within."

Slavov and his team use automation to identify, label, and categorize their analysis of cellular proteins to encourage supervised machine learning that can discern on its own what is significant.

"Fundamentally, any biological system is very complex, and science has had less success understanding complex systems," says Slavov "With AI, the hope is that we can better understand the physical interactions between molecules, which can be broadly applicable to any disease and early human development."

Slavov's research has been funded by the Chan Zuckerberg Initiative, and he was recently named a prestigious Allen Distinguished Investigator and was awarded a $1.5 million three-year grant to further his novel research.

Better treatment of disease

For more than a decade, Professor **Jennifer Dy**, electrical and computer engineering, has been working on a better way to identify and treat skin cancer. With her expertise in machine learning, Dy has been collaborating with optical engineer Dr. Milind Rajadhyaksha at the Memorial Sloan Kettering Cancer Center in New York, as well as a biomedical imaging colleague at Northeastern, Research Professor **Dana Brooks** of electrical and computer engineering.

The standard workflow for diagnosing skin cancer is dermoscopy using light, magnification, and the human eye, and often removing tissue for deeper inspection. Dy's colleague in optical engineering is perfecting the use of reflectance confocal microscopy (RCM), which is newer equipment (and now a reimbursable procedure with a healthcare insurance billing code provided in 2017) that allows doctors to see lesions under the skin, minimizing the need for biopsy.

"While RCM is considered to be more effective and certainly less invasive, not many doctors are trained to use the equipment and analyze the 3D, grayscale images," says Dy. "We're applying AI and machine learning to automate where the dermal-epidermal junction is—which is usually where skin cancer starts and varies from person to person and from site to site—as well as detect patterns that signify cancerous areas."

In another collaboration, Dy is partnering with experts in chronic obstructive pulmonary disease (COPD), which is a chronic lung function disease caused by smoking or the inhalation of pollution and other noxious particles. Doctors believe that COPD is heterogenous—meaning that people react differently to it based on unknown factors—and want to better stratify patients to offer them more effective treatments.

Together with Brigham & Women's Hospital, Dy is a part of the COPDGene® Study, which is an NIH-funded investigation into possible genetic signifiers that effect disease progression. Researchers are collecting high-resolution computed tomography images, genetic data, and clinical data from a cohort of patients at 21 sites across the U.S., and it's Dy's group's job to help use machine learning to understand COPD from this mountain of data.

"We're looking at 10,000 patients with three different modalities over three separate time points and using AI to look for patterns that can help us discover COPD subtypes," says Dy. "This is a rich problem from a modeling point of view in that there are thousands of possible relevant features in each modality, and we have to design methods to teach a computer how to decide which ones are important."

While this particular study will clearly benefit the field of COPD disease research, Dy's work on this difficult problem can help to advance machine learning as a field.

"While we are using machine learning to help make sense of the data we are giving it, we're also focused on making it clearer how the computer arrives at its decisions," explains Dy. "By showing doctors how the machine draws its conclusions, we're able to also get their input and expertise on whether its methodology makes sense and helps them both understand and verify COPD's characteristics."

"We're looking at 10,000 patients with three different modalities over three separate time points and using AI to look for patterns that can help us discover COPD subtypes."

Jennifer Dy
professor, electrical and computer engineering

"Of the many people dying in the U.S. because of opioid overdose, more than 30% have been from prescribed medication. So, our first step is to make sure that physicians are appropriately identifying patients who have the potential to misuse the drug."

Md Noor E Alam
assistant professor, mechanical and industrial engineering

Improving a nationwide health crisis

Assistant Professor **Md Noor E Alam**, mechanical and industrial engineering, is using machine learning techniques to analyze large-scale healthcare data and identity determinants that lead to opioid overdose.

Working from large-scale healthcare claim data from 0.6 million patients, the research team has identified 30 prominent features that may help indicate the possibility of opioid overdose in future patients. Many align with existing knowledge about opioid addiction behavior and some are brand new—and occasionally controversial—such as a history of certain mental illnesses and vaccinations.

Alam's project is not only seeking to predict potential overdoses, but also taking a systems approach to see how they can help to address the nationwide issue on opioid addiction. Some of these projects are funded by the Centers for Disease Control in partnership with the Massachusetts Department of Public Health.

"Of the many people dying in the U.S. because of opioid overdose, more than 30% have been from prescribed medication," says Alam. "So, our first step is to make sure that physicians are appropriately identifying patients who have the potential to misuse the drug."

Because conventional machine learning algorithms can't capture the clinical trajectories with co-occurring conditions of a patient's health history, Alam is currently working with his student **Md Mahmudul Hasan**, PhD'21, industrial engineering, to develop deep learning technology to overcome this limitation.

"We're planning to provide physicians with a visual tool to help them predict and better understand the current condition of their patients," says Alam. "Once the deep learning is developed, we're going to create an interface for them to evaluate the technology and help us finetune it to incorporate their important domain knowledge."

Alam hopes that this research can not only help to lower the rate of opioid overdoses in the U.S., but also offer patients better treatment with less addictive drugs and prevent unwanted prescription opiates from entering the black market. ■

Making Machine Learning Safer for More Applications

Xue "Shelley" Lin, assistant professor, electrical and computer engineering

Artificial intelligence and machine learning are two of the most exciting developing technologies in the world. From self-driving cars, to robotics, to healthcare, their potential to help people is virtually unlimited.

As with many technologies, however, it comes with potential security issues. The threats for machine learning come in many forms, but can be broken down into machine-centric and human-centric attacks. As you might guess, machine-centric attacks target machine learning decisions, and human-centric attacks aim to fool humans making decisions. Both types of attacks aim at "information deception"–manipulating the input data on machine learning models or producing falsified media and other information with machine learning models.

Countering these attacks is at the heart of Electrical and Computer Engineering Assistant Professor **Xue "Shelley" Lin's** research that she is doing in collaboration with Michigan State University Professors Xiaoming Liu and Sijia Liu. The project, titled "Intelligent Diagnosis for Machine and Human-Centric Adversaries", recently received $1 million in funding from the Defense Advanced Research Projects Agency (DARPA), and will build a scalable learning system for reverse engineering of deception (RED). It aims to develop and scale technology that can automatically recover and index attack toolchain signatures in both machine-centric and human-centric attacks.

Before getting into solutions, let's see what these attacks can look like. One of the major attack types involves falsified media. Adversaries can use machine learning algorithms to produce fake media, like a fake piece of news or fake images. The attack's goal is to fool humans, for example, making it look like they're saying something that isn't true.

Adversaries can also produce data to fool machine learning algorithms. "For example, we can add very minor manipulations to a panda image," Lin explains. "The image still looks like a panda to people, but the machine learning algorithm will identify it as another animal."

These types of attacks involve the execution phase of a machine model. The model itself isn't changed, but because of the machine learning algorithms, it's possible to find images to fool the machine learning models.

Another type of attack is implemented during the training of machine learning models. In this phase, developers use training data to build a model that will execute tasks. Adversaries execute these attacks by manipulating the training data itself.

"The training phase attack can be done by replacing a small portion of the training data–as little as five or 10 percent," Lin details. "We can, for example, put a very small cross in a corner of the images, and that will change the label of the image to the wrong label. Then when the model is trained, whenever an image has a cross in the corner, the model will attach the wrong label to the information."

The project will develop ways to identify these attacks, and others, and also index them for future use.

"Our project is the first one to develop a unified attack toolchain that covers a broad range of attacks, both human-centric and machine-centric," Lin says. "And then to index each attack, we have different families of attacks, and even reverse engineer the data to extract the unique adversary signature, and also the supervised attack classifier."

In the end, this project should help make machine learning safer to use for a wider variety of tasks.

"Machine learning can be powerful, but there are many uncertainties holding us back from using it more widely," Lin says. "We need to gain more understanding of it and the potential security issues to use it more confidently. This project is about helping in the fundamental direction of being able to use it more."

photo by Ruby Wallau

EXPANDING THE GLOBAL NETWORK

From adding state-of-the-art facilities to partnering university-wide and with industry, government, and academia, as well as expanding education opportunities globally, Northeastern's College of Engineering continues to push innovation and experiential learning to new bounds. In this section, we highlight a few exciting recent developments:

photo by Matthew Modoono

Fostering Innovation through Collaboration

Located at the Innovation Campus in Burlington, Massachusetts, Northeastern's George G. Kostas Research Institute, commonly known as KRI, brings together university-wide faculty and students, with industry and government to help solve important security, intelligence, and resilience challenges. KRI is home to several of Northeastern's engineering research centers and labs, including the Center for High-Rate Nanomanufacturing; Colosseum, the world's largest wireless testbed built by DARPA; the Awareness and Localization of Explosives Related Threats (ALERT) research center lab; and the Laboratory for Structural Testing of Resilient and Sustainable Systems—the largest of its kind east of the National Earthquake Center.

KRI's approach to partnership is highlighted in the variety of partners who are an integrated component of the collaborative ecosystem. Along with several onsite government labs—such as the Army Research Lab Northeast and Air Force Counter Small-UAS and Air Force Systems Integration Lab—KRI has 22 industry partners across its campus, among them Raytheon Technologies, Rogers Corporation, VRC Metal Systems, and AeroVironment. These partnerships are critical to "accelerating academic discoveries into practical use," says KRI CEO **Peter Boynton**.

In recent years, the Innovation Campus added an Expeditionary Cyber & Unmanned Aircraft Systems Lab—the first of its kind in the United States. Ongoing renovations also added 30,000 square feet of entrepreneurial space—the Venture Creation Center, furthering innovation opportunities for engineering faculty, students, and alumni.

Venture Creation Center

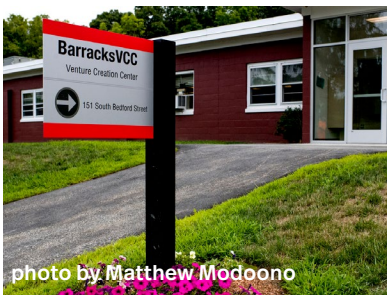
In 2015, Northeastern established the first "venture creation center" in Burlington, converting a 1950s-era U.S. Army barracks building, part of the 14-acre former Nike missile base—acquired by the university in the 1960s—that forms the current campus.

With a mission to create an affordable space where entrepreneurs would have access to KRI's partner networks and the talent and expertise of Northeastern faculty and students, the KRI team conducted a low-cost renovation, brought the building up to code, and filled it with second-hand furniture. "We weren't building a showcase," explains Boynton. "It's a place to innovate."

Entrepreneurs from Northeastern—both faculty and alumni—flocked to the space, eager to take advantage of the facility and its resources. The 10,000-square-foot space, known as Barracks 1, soon filled.

Seeking out additional space, Northeastern found an ideal solution in Elliott Hall—the former site for continuing education—and its 20,000 square feet of unused classroom and faculty office space. The KRI team again kept it simple, bringing the building—now known as Barracks 2—up to code and providing the basics.

Barracks 1 offers shared wet lab space and additional fume hoods for wet chemistry while Barracks 2 currently has maker space and electronics lab space with plans to add wet chemistry. Spaces range from approximately 130 square feet to 700-800-plus square feet and everything in between.



The 30,000 sq. ft. Venture Creation Center is located in the Barracks buildings.

Boynton likens the environment to a vibrant neighborhood full of constant activity where spinouts can "thrive in an innovation ecosystem." His team conducts monthly, 30-minute lunch-and-learns via Zoom where founders highlight what their companies are doing. A wide variety of participants, ranging from scientists to faculty, administrators, and industry/government partners, attend the sessions that Boynton describes as both informative and inspirational.

"The company founders say they imagine this place is what Steve Jobs' garage must have looked like," says Boynton. "It's exactly what they need: a place to do work at a price they can afford."

Currently there are 16 "spinouts" or early-stage companies in resident at KRI and here we highlight just a few.

Evergreens is a startup located at KRI. Northeastern alumnus **Ahmad Zameli**, E'14, industrial engineering, was intrigued by the challenges inherent in the supply chain for fresh food, particularly in Saudi Arabia where he grew up and where much of the produce is flown in from Europe. Seeking a solution to bring fresher food back home and make the food system more resilient, Zameli founded Evergreens to develop indoor crops without sun, soil, or pesticides for chemical and GMO-free fresh produce close to points of consumption and cut seed-to-harvest cycle times.

At KRI he found a perfect space for his company in Barracks 1, a robust talent pipeline, valuable connections, and a supportive network. "As a young company, to go out on your own, it's very intimidating and if you want to be part of the community, it's expensive," he says. "Northeastern was the best of both worlds."

Today, Zameli and his team are on the cusp of commercial production with three farms on campus growing strawberries, lettuce, arugula, and other greens. His core team includes five

"As a young company, to go out on your own, it's very intimidating and if you want to be part of the community, it's expensive. Northeastern was the best of both worlds."

Ahmad Zameli
E'14, industrial engineering

photo by Adam Glanzman

Jeffrey Ruberti, professor, bioengineering and Patrick Bradley, PhD'19, bioengineering

full-time employees: three Northeastern alumni, a product manager, and a former co-op student. Zameli notes that over the past four years his venture has drawn co-ops from diverse fields, including business, computer science, and environmental science.

"We were one of the first research partners to come on campus," says Zameli. "We've created a special bond with KRI and I hope it will continue to grow. KRI played a major role in our success."

Bioengineering Professor **Jeffrey Ruberti** studies collagen, specifically its ability to work on its own as a self-healing material. RegenX, his spinout at KRI, is an extension of the work that Ruberti has been doing in his lab for the past 15 years. "It takes the central pillar of my research and turns it into a product that could be useful in repairing tissue," he says of the biotechnology company he founded with his former student **Patrick Bradley**, PhD'19, bioengineering, and Dr. Adam Hacking, a former Harvard researcher who now serves as CEO.

Collagen was long assumed to be a dead protein. "Turns out, that's not true," says Ruberti. "It's constantly in flux. We've done research in the lab to show that collagen is energetically tuned to end up where it's supposed to be. If you've torn a ligament, collagen will hone-in on the injury to aid in repair."

The core team in Burlington currently comprises two bioengineering co-ops and co-founders Bradley and Hacking. Twenty students from four capstone groups in bioengineering have worked on projects to support RegenX's mission. Ruberti notes that one of these teams came up with a solution for one of the company's biggest challenges—securing a human collagen source—by devising a way to CRISPR human cells to "get them to crank up production of collagen so the cost point is low."

Ruberti says that KRI's service-oriented philosophy, nurturing environment, flexibility and affordability made the decision to base RegenX at KRI an easy one. "We looked at other spaces…they weren't even close. There's more space here for less money…we can do everything we want to do." He adds, "If we're successful, it's due in large part because we were able to come over to KRI."

Boston Materials "graduated" from KRI in 2017 with the commercial introduction of a new Z-axis carbon

fiber material that can be used to make a variety of lightweight yet durable products, from airplane wings to wind turbines.

Co-founded by Mechanical and Industrial Engineering Associate Professor **Randall Erb** and alumni **Michael Segal**, E'16, and **Anvesh Gurijala**, E'16, Boston Materials took up residence in 300-600 square feet of space in Barracks 1. The team quickly made progress, and one year later they launched the company, first moving to nearby Bedford and then to their current home, a 37,000-square-foot facility in Billerica.

Like many of KRI's spinout founders, Erb says the company benefited greatly from the affordability of lab space; access to the KRI ecosystem that allowed them to advance their technology through collaboration with industry partners such as Rogers Corporation and others; and the ability to tap into a talent pool of Northeastern co-ops. Another advantage, he says, is the economic benefit of having access to materials characterization equipment on site to prove out their platform.

"We really see KRI as an enabler in our storyline," says Erb. "The network we created through the KRI experience will continue. Even though we've twice graduated, we're still strongly interacting with the KRI community."

The Expeditionary Cyber & Unmanned Aircraft Systems Lab

A 1.8 million cubic-foot outdoor test cage with flight path to the 50'x50'x22' indoor anechoic chamber, the Expeditionary Cyber and Unmanned Aircraft Systems (UAS) Lab, funded by the U.S. Navy Office of Naval Research, is the first of its kind in the United States. It is designed for military and business leaders to partner with the university in cyber-security testing on drones. In 2019, The Air Force Life Cycle Management Center provided a $2.8 million grant to fund research through its unit at nearby Hanscom Air Force Base.

The walls, floor, and ceiling of the radio-silent drone testing facility are lined with hundreds of blue protruding arrowheads, made of foam, which are designed to absorb radio frequency waves. They transform the square room into an anechoic chamber that enable government and private researchers to join with Northeastern and other universities in creating defenses against potential drone attacks. The facility is also encased with a Faraday cage of conducting material that creates an electromagnetic shield.

The indoor facility is connected to a netted enclosure outdoors, measuring 150 feet by 200 feet—large enough for GPS testing. Drones can be navigated in and out between the two areas for seamless exercises in all conditions. Additionally, sophisticated equipment enables researchers to understand expeditionary cyber, including handling electromagnetics and cyber over a very large frequency range; effects on navigation; and effects on global positioning signals, and how those can be corrupted at the expeditionary edge.

William Lincoln Smith Professor **Tommaso Melodia**, electrical and computer engineering, and director of the Institute for the Wireless Internet of Things, conducts research on unmanned aerial systems and on using

Randall Erb, associate professor, mechanical and industrial engineering

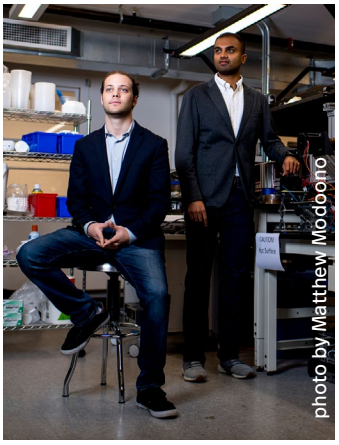


photo by Matthew Modoono

Michael Segal, E'16, and Anvesh Gurijala, E'16, mechanical and industrial engineering

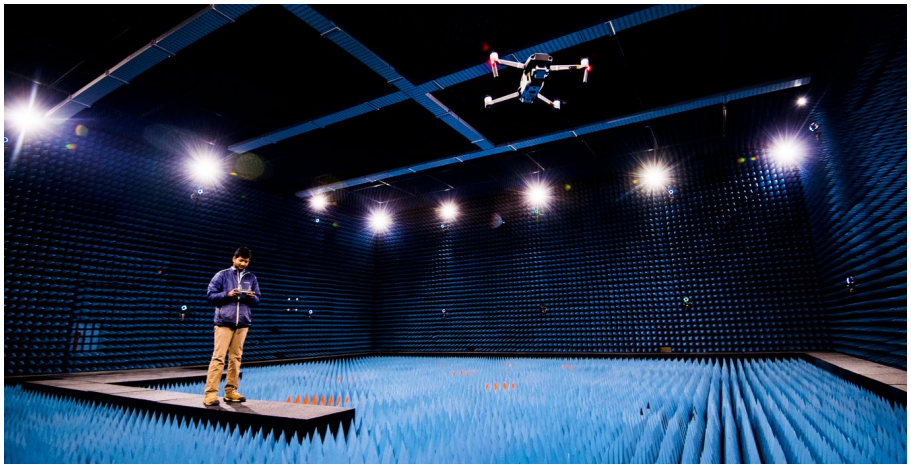
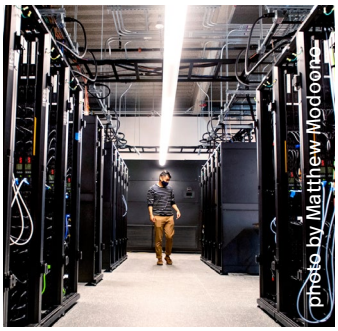


photo by Adam Glanzman

The indoor anechoic chamber of the Expeditionary Cyber and Unmanned Aircraft Systems Lab



Colosseum, the world's largest radio frequency emulator, is located at the Innovation Campus in Burlington, Massachusetts, and is part of the Institute for the Wireless Internet of Things, directed by William Lincoln Smith Professor Tommaso Melodia, electrical and computer engineering.

"I've used the UAS Lab for several research projects, different drone applications, and to experiment with diverse wireless technologies. I couldn't have carried out my research anywhere else."

Lorenzo Bertizzolo
PhD'21, computer engineering

drones to create new applications for societal benefit. "As a user of the UAS lab, my work is at the intersection of autonomous robotic drones and connectivity; how these drones are connected with each other so they can exchange information," says Melodia. "We're working on new technologies to connect drones that operate at a high frequency rate—specifically 16 GHz—that's known as millimeter-wave communications, one of the foundational technologies for 5G and beyond. What this facility enables us to do is fly drones of different sizes that carry payloads, like millimeter-wave radios, and test their performance."

Among the applications that Melodia and his team are working on are creating an on-demand mobile network of drones to provide additional wireless connectivity in specific locations when needed. They are also looking at using drones to provide connectivity in disaster scenarios. For example, in catastrophic hurricanes where entire wireless networks are wiped out, a network of drones could provide temporary connectivity to help locate survivors or provide disaster relief.

Melodia and his team fly connected drones in the large anechoic chamber and its Faraday cage, which prevents signals generated outside to get inside the chamber. "That means you get a much higher fidelity performance because there's no interference," he says. It's a great tool for doing research in this space and for evaluating use cases."

Likewise, the outdoor facility provides the team with the ability to fly multiple drones in a controlled situation. "We conducted a demo for the Air Force with eight different drones flying in this environment," says Melodia. "We could not have created a credible demo without access to a facility of this size."

Graduate student **Lorenzo Bertizzolo**, PhD'21, computer engineering, agrees with Melodia regarding the benefits of the UAS lab. "I've used the UAS Lab for several research projects, different drone applications, and to experiment with diverse wireless technologies," he says. "I took advantage of the indoor and the outdoor areas alike, tested single- and multi-drone swarms, and explored innovative drone-based solutions for future wireless technologies like 5G and millimeter-wave. I couldn't have carried out my research anywhere else." ■

One Program, Two PhDs on Two Continents

Northeastern's new international doctorate program—the Global Experiential PhD—provides students with an opportunity to earn separate PhDs from two universities in two continents while dramatically expanding the breadth of their research. As an added benefit, the program also expands the international job opportunities for graduates.

"It's like having two passports," says Associate Professor of Electrical and Computer Engineering **Stefano Basagni**, a thesis research advisor in the program. "To get a job at an American company, it helps if you have an American PhD, and the same is largely true of a European degree in the European Union."

For **Irene Tallini**, PhD'24, computer engineering, the program provides the opportunity to conduct research in the United States while maintaining her relationship with Sapienza University of Rome, where she earned both her undergraduate and master's degrees.

"This program provides huge intercultural opportunities," Tallini says. "The professors in Northeastern's Electrical and Computer Engineering department are experts in their sectors and I'm also excited about having access to the university's unique facilities."

As an engineer focused on wireless communication among underwater and aerial drones, Tallini is particularly interested in Colosseum, the world's largest radio frequencies emulator (which is part of Northeastern's Institute for the Wireless Internet of Things), and the Cyber and Unmanned Aircraft Systems R&D facility, both of which are situated at Northeastern's Innovation Campus in Burlington, Massachusetts.

Because students spend half of their time at each institution, they are exposed to two different research cultures and the expertise of faculty with different areas of specialization. The program is also intentionally flexible to enable interdisciplinary research, thereby allowing students to pursue research in different fields at each institution. They must apply to each program independently and fulfill all of the academic requirements of both programs. Under the supervision of a research supervisor from each institution, they write a single dissertation that earns them a separate PhD in each country.

The first two partners with the Northeastern program are Sapienza University of Rome and the University of Hong Kong. So far four students from these institutions have enrolled at Northeastern, including three engineering students from Sapienza who began in Rome and will come to Boston for the summer semester of 2021. There are additional partnerships in the works.

"Northeastern is building a selective network of educational institutions around the globe," says Vice Provost **Sara Wadia-Fascetti**, who is head of Northeastern's PhD Network. "We are a global institution—a networked institution. This increases mobility for our students and further extends our research outside Boston."

"This program is based on the concept of convergence, which is a key component of interdisciplinary research," says Wadia-Fascetti. "It's important to maximize a student's exposure to many different concepts and cultural experiences that connect ideas to one another and translate disciplines to one another. This exposure influences both the scope and direction of their research."

Students aren't the only ones who benefit from these partnerships, says Associate Professor of Civil and Environmental Engineering **Luca Caracoglia**, who along with Basagni has a longstanding relationship with Sapienza University and helped spearhead the new partnership.

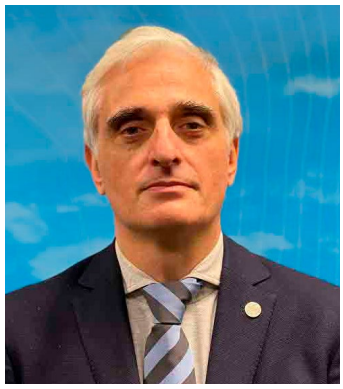
Caracoglia, who is an expert on wind engineering and wind load effects, recently hosted a workshop bringing together Northeastern and Sapienza faculty who focus in structural engineering and geotechnical/geo-environmental engineering and who are currently advising civil engineering PhD students.

"For faculty, it's a way to bring new perspectives to our research ideas and collaborate with experts in Italy through our students," Caracoglia says.

Basagni agrees, adding that the program also provides important benefits for the university as a whole. "This is a way to attract the best students from universities around the world while enhancing our international visibility and connectedness."

Stefano Basagni, associate professor, electrical and computer engineering

Sara Wadia-Fascetti, vice provost, PhD Network, and professor, civil and environmental engineering



Luca Caracoglia, associate professor, civil and environmental engineering

Pioneering an AI Research Hub

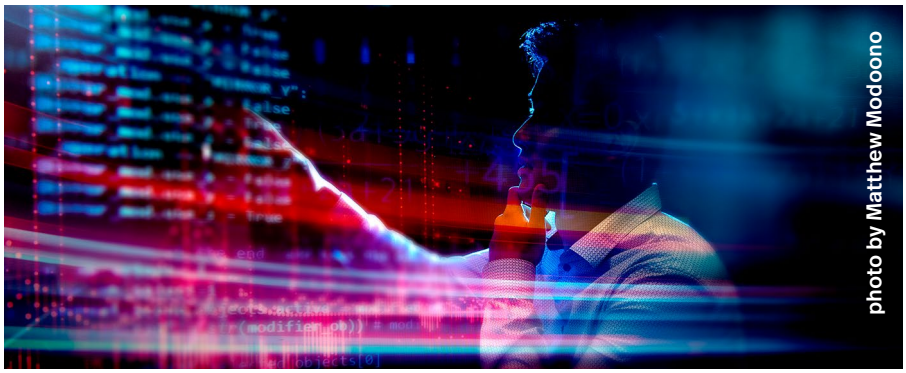


photo by Matthew Modoono

The Institute for Experiential AI at Northeastern University

Northeastern's new Institute for Experiential Artificial Intelligence is a pioneering research hub focused on application-driven, human-centered AI that places human skills and intelligence at the forefront of AI development. The university is allocating $50 million for the new Institute, in which leading experts in the engineering, computer science, humanities, law, public policy, AI, health, security, and sustainability collaborate to develop solutions to the world's challenges.

The Institute for Experiential AI is university-wide and based out of the Roux Institute at Northeastern—a graduate education and research campus in Portland, Maine, made possible through a $100 million investment in the university from **David** and **Barbara Roux**. The Roux Institute is designed to educate generations of talent for the digital and life sciences sectors, and drive sustained economic growth in Portland, the state of Maine, and northern New England.

"Northeastern is committed to building the top research institute in the world when it comes to experiential AI. One of the reasons I'm excited about that is because no one has yet claimed the space. There is a chance to be the leader [in the field]," says **Usama Fayyad**, the executive director for the Institute of Experiential AI.

The Institute for Experiential AI is recruiting 30 new research and teaching faculty, data scientists, and postdoctoral fellows. Faculty from the Colleges of Engineering and Khoury College of Computer Sciences, among other disciplines, are conducting and collaborating on multidisciplinary research as part of the Institute. The aim is to accelerate research and applications through pragmatic applications of AI in several domains.

The Institute plans to partner with industry, government, and academia to lead the effort in creating human-in-the-loop AI solutions that are used ethically and responsibly, and in educating the next generation of AI professionals. The Institute also aims to be a major contributor to the AI ecosystem globally, and through activities targeted in the region, an important driver of the field in New England.

FACULTY SPOTLIGHT

Yang Zhang, professor, civil and environmental engineering

Atmospheric Modeling to Improve Air Quality

BY DAVID DEETER

Globally, air quality impacts all aspects of life, from public health to the economy. Professor **Yang Zhang**, who joined Northeastern University's Department of Civil and Environmental Engineering in 2020 as a Distinguished Fellow, researches atmospheric/climate modeling and air quality forecasting. She brings years of leadership in this important field to a growing and diverse range of environmental engineering expertise within the department.

Zhang's recent research, funded by the National Science Foundation and the United States Department of Agriculture, revealed an estimated $1 billion a year shortfall in U.S. perennial crop yields due to ozone pollution, and has estimated over 63,000 saved lives and over $500 billion saved costs through reducing surface fine particle levels by a few µg m-3. Additionally, a 2020 paper published in the journal *Nature Climate Change* by Zhang and collaborators identified how policy changes towards pollutants in China could save upwards of 13,000 lives a year.

Understanding, monitoring, and forecasting air quality require complex tools and massive computing power. Over her career, Zhang has served at the forefront of the endeavor to understand the atmosphere and has contributed to the development of many of the now essential techniques and modeling practices used frequently within the field. Commissioned by the UN's World Meteorological Organization (WMO), in 2020 Zhang published a training book titled, "Training Materials and Best Practices for Chemical Weather/Air Quality Forecasting." As a member of the WMO's Global Air Quality Forecasting and Information System Initiative (GAFIS), she is co-leading WMO's effort in capacity building for air quality forecasting and information systems which includes skill training, scientific advancement, and transformation of research to operations.

Zhang is looking to further move our understanding of atmospheric chemistry and air quality. From her Clean Air, Smart City, And Digital Earth (CASCADE) Lab on Northeastern's Boston campus, she is charting the next frontier of air quality monitoring and forecasting at hyperlocal scales such as at home, in buildings, and on streets.

"Traditionally, air quality monitoring and modeling are done at the regional and urban scale or larger," explains Zhang. But she envisions a new transdisciplinary system in which we develop the tools to monitor the quality of the air we breathe at critical points throughout a city.

"Air quality can vary greatly even over relatively small distances," says Zhang. "The quality of air on the sidewalk outside a building can be quite different from that measured at a window a few stories above."

Such a surveillance system could help policymakers design cleaner cities and help public health officials better understand the effects of exposure to polluted air on long-term health outcomes at hyperlocal scales.

Her plans pair well with the department's focus on Urban Engineering, whereby legacy approaches to civil and environmental engineering are enhanced by new strategies and solutions for larger-scale urban growth, renewal, health, resilience, and sustainability.

WELCOME NEW FACULTY

GREGORY ABOWD
Dean, College of Engineering;
Professor, electrical and computer engineering
PhD, University of Oxford

RUOBING BAI
Assistant Professor, mechanical and industrial engineering
PhD, Harvard University

SIDDHARTHA GHOSH
Assistant Professor, electrical and computer engineering
PhD, Carnegie Mellon University

AILEEN HUANG-SAAD
Associate Professor, bioengineering
Director of Life Science and Engineering Programs, Roux Institute
PhD, Johns Hopkins University

JULIA HOPKINS
Assistant Professor, civil and environmental engineering
PhD, Massachusetts Institute of Technology

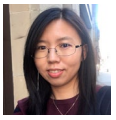
DIMITRIOS KOUTSONIKOLAS
Associate Professor, electrical and computer engineering
PhD, Purdue University

LAURENT LESSARD
Associate Professor, mechanical and industrial engineering
PhD, Stanford University

ELIZABETH LIBBY
Assistant Professor, bioengineering
PhD, University of Pennsylvania

MINGYANG LU
Assistant Professor, bioengineering
PhD, Baylor University

FRANCESCO RESTUCCIA
Assistant Professor, electrical and computer engineering
PhD, Missouri University of Science and Technology



LILI SU
Assistant Professor, electrical and computer engineering
PhD, University of Illinois

HONGWEI SUN
Professor, mechanical and industrial engineering
PhD, Institute of Engineering Thermophysics, Chinese Academy of Sciences

XIAOYU TANG
Assistant Professor, mechanical and industrial engineering
PhD, Princeton University

REBECCA KUNTZ WILLITS
Professor and Chair, chemical engineering
PhD, Cornell University

XIAOLIN XU
Assistant Professor, electrical and computer engineering
PhD, University of Massachusetts, Amherst

Faculty Promotions

UNIVERSITY DISTINGUISHED PROFESSOR

MANSOOR AMIJI
chemical engineering

PROFESSOR

EDWARD BEIGHLEY
civil and environmental engineering

KAUSHIK CHOWDHURY
electrical and computer engineering

MATTEO RINALDI
electrical and computer engineering

ASSOCIATE PROFESSOR

QIANQIAN FANG
bioengineering

DAVID FANNON
civil and environmental engineering

LORETTA FERNANDEZ
civil and environmental engineering

JACQUELINE GRIFFIN
mechanical and industrial engineering

CARLOS HIDROVO CHAVEZ
mechanical and industrial engineering

STRATIS IOANNIDIS
electrical and computer engineering

MARK NIEDRE
bioengineering

YOUNG INVESTIGATOR RECOGNITIONS

Assistant Professor **Mahshid Amirabadi**, electrical and computer engineering, received a $400K National Science Foundation CAREER Award for "Universal SiC-Based Power Converters for Renewable Energy Systems." The research will create high power density and ultra-reliable converters by combining wide-bandgap devices with new universal converter topologies that have an ability to eliminate less reliable components commonly used in power. *See page 12.*

Assistant Professor **Abigail Koppes**, chemical engineering, received a $500K National Science Foundation CAREER Award for "Defining the Regulators of Enteric Plasticity in Engineered Microfluidic Environments." *See page 9*. She also received the Rita Schaffer Young Investigator Award from the Biomedical Engineering Society.

Assistant Professor **Cristian Cassella**, electrical and computer engineering, received a $409K National Science Foundation CAREER award for "Giant Tunability through Piezoelectric Resonant Acoustic Metamaterials for Radio Frequency Adaptive Integrated Electronics." He will develop a new class of passive, tunable, and high-performance integrated resonant devices, namely the Piezoelectric Resonant Acoustic Metamaterials (pRAMs). *See page 11*.

DiPietro Assistant Professor **Joshua Gallaway**, chemical engineering, received a $400K National Science Foundation CAREER award for "Engineering Electrochemical Reversibility in Disordered Materials for High Energy Density Batteries." The project will conduct research on advanced battery materials that have the potential for greater energy density and cycle life, while operating in non-flammable water-based electrolytes. *See page 10*.

Assistant Professor **Michael Kane**, civil and environmental engineering, was awarded a $763K National Science Foundation CAREER Award for "Human-Centric Automation in the Built Environment." The project will enable the design of automation in the built environment that models human physiological and behavioral responses to changing environmental temperature conditions to satisfy competing objectives of energy management and occupant comfort. *See page 12*.

Assistant Professor **Hari Parameswaran**, bioengineering, received a $603K National Science Foundation CAREER Award for "Elucidating the Role of Collective Cell-Matrix Interactions in the Mechanobiology of Airway Narrowing." The project aims to reveal how physical forces enable the airway smooth muscle and the surrounding tissue to work together to detect inhaled irritants and regulate the constriction of airways. *See page 8*.

Assistant Professor **Benjamin Woolston**, chemical engineering, received the Jay Bailey Young Investigator Award in Metabolic Engineering within the International Metabolic Engineering Society. The award recognizes outstanding research accomplishments in the field of metabolic engineering by a young investigator who has advanced the frontiers of metabolic engineering through originality and creativity of experimental or computational concept application.

RECENT FELLOWS

Selected engineering faculty who have been elected as Fellows of national professional societies.

David Luzzi, senior vice provost for research and vice president of the Innovation Campus at Burlington, and professor of mechanical and industrial engineering, was named a Fellow of the National Academy of Inventors (NAI). The NAI Fellows Program highlights academic inventors who have demonstrated a spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development, and the welfare of society. Election to NAI Fellow is the highest professional distinction accorded solely to academic inventors.

Professor **Hameed Metghalchi**, mechanical and industrial engineering, was selected as an Honorary Fellow of the International Society for Energy, Environment and Sustainability for the class of 2020, for pioneering research and education in thermodynamics and combustion for the last four decades, improving thermal system efficiency and effectiveness, while reducing pollutant formation.

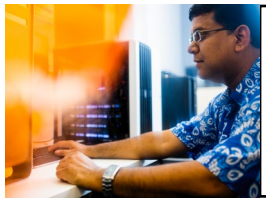
FACULTY NEWS

Selected Highlights

Professor **Heather Clark**, bioengineering, jointly appointed in chemistry and chemical biology, and director of Northeastern University's Institute for Chemical Imaging of Living Systems, was named a 2021 American Institute for Medical and Biological Engineering (AIMBE) Fellow. She was nominated, reviewed, and elected by peers and members of the College of Fellows for the development of nanoscale optical probes for chemical imaging within live cellular and tissue environments.

Professor and Department Chair **Rebecca Kuntz Willits**, chemical engineering, was selected as a Fellow of the Biomedical Engineering Society. Fellows have demonstrated exceptional achievements and made significant contributions within the biomedical engineering field. They also have extensive leadership within the field and have served within the BMES.

Professor **Luca Caracoglia**, civil and environmental engineering, was selected as a Fellow of the American Society of Civil Engineers for his contributions in research, education, and outreach in the areas of structural engineering, structural dynamics, probabilistic mechanics, wind engineering and wind energy.



Professor **Auroop Ganguly**, civil and environmental engineering, is leading a $3 million grant for "NICE: Networked Infrastructures under Compound Extremes" from the DoD's Strategic Environmental Research and Development Program (SERDP).

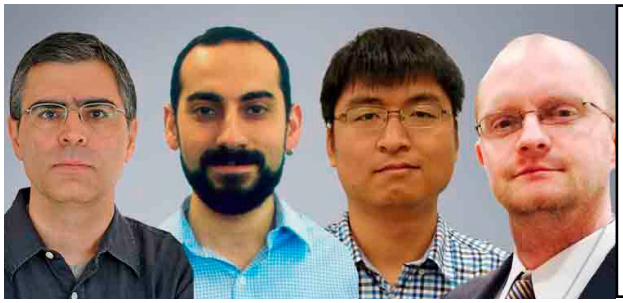
Jerome Hajjar, CDM Smith Professor and Department Chair, civil and environmental engineering, was honored with the American Institute of Steel Construction 2021 Lifetime Achievement Award for his impact on AISC and the structural industry as a whole. The award bestows a special recognition to individuals who have provided outstanding leadership over a sustained period of years to AISC and the structural steel design, construction, and academic community.

University Distinguished and William Lincoln Smith Professor **Vincent Harris**, electrical and computer engineering, was named a Senior Member of the National Academy of Inventors. NAI Senior Members are active faculty, scientists and administrators from NAI member institutions who have demonstrated remarkable innovation producing technologies that have brought, or aspire to bring, real impact on the welfare of society. They also have growing success in patents, licensing, and commercialization.

Professor **Peter Furth**, civil and environmental engineering, was awarded the 2020 Lifetime Achievement Award by the Association of Pedestrian and Bicycle Professionals (APBP). The award was conferred for Furth's "enthusiasm as an educator, advocate, and researcher who elevated the discourse for better bicycling and walking while empowering professionals with proven research."

Assistant Professor **Nikolai Slavov**, bioengineering, was named a prestigious Allen Distinguished Investigator and was awarded a $1.5 million three-year grant to further his novel research on single cell proteomics. The Paul G. Allen Frontiers Group supports early-stage research with the potential to reinvent entire fields. Slavov is the first from Northeastern to receive the award.

Assistant Professor **Kayse Lee Maass**, mechanical and industrial engineering, in collaboration with Northeastern's College of Social Sciences and Humanities, is a co-principal investigator of a $759K National Institute of Justice grant, titled "Identification of Effective Strategies to Disrupt Recruitment of Victims in Human Trafficking: Qualitative Data, Systems Modeling, Survivors and Law Enforcement." Maass is also co-PI on a $1 million National Science Foundation multi-university collaborative grant, titled "Modeling Effective Network Disruptions for Human Trafficking."

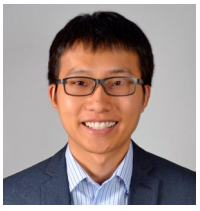


The Mechanical and Industrial Engineering Cold Spray Research Group, including **Sinan Muftu**, professor and associate dean for faculty affairs; **Ozan Ozdemir**, assistant research professor; **Enqiang Lin**, assistant research professor; and **Andrew Gouldstone**, professor and associate chair of experiential innovation, received a $999K grant from the National Institute of Standards and Technology to improve sensing approaches and create a suite of sensor technologies that will help optimize cold spray additive manufacturing.

Professor and Department Chair **Srinivas Tadigadapa**, electrical and computer engineering, received the 2020 IEEE Sensors Council Meritorious Service Award for his outstanding long-term service to the IEEE Sensors Council.

Professor **Fabrizio Lombardi**, electrical and computer engineering, was selected as president-elect for 2021 and president for 2022-2023 of the IEEE Nanotechnology Council, the vice president for 2021 of the IEEE Computer Society, and was one of three elected as a member of IEEE of the 2021 Publications Services and Product Board.

Assistant Professor **Ambika Bajpayee**, bioengineering, in collaboration with the University of Arkansas for Medical Sciences, was awarded a $2.2 million grant from the National Institute of Arthritis and Musculoskeletal and Skin Diseases for "Intra-Cartilage Depot Delivery of Electrically-Charged IL-1RA for Targeting Osteoarthritis-Associated Inflammation and Catabolism in Multiple Joint Tissues."



Hui Fang, assistant professor of electrical and computer engineering, and **Ryan Koppes**, assistant professor of chemical engineering, received a $2.2 million National Institutes of Health grant in collaboration with University of California, Los Angeles and Boston Children's Hospital for "Novel Transparent, Ultra-soft Neuroelectrode Arrays Based on Nanomeshing Conventional Electrode Materials."

Professor **Mieczyslaw Kokar**, electrical and computer engineering, received a $1.2 million award from the Defense Advanced Research Projects Agency to work on the Intent-Defined Adaptive Software (IDAS) program. The award is part of a larger award to SNC. The overall IDAS goal is to automate code generation, derived from software intent and associated constraints, to rapidly adapt to late changes in requirements and operating environments.

Professor **Sagar Kamarthi**, mechanical and industrial engineering, is selected the winner of the 2021 Data Analytics & Information Systems (DAIS) Data Analytics Teaching Award from the DAIS division of the Institute of Industrial and Systems Engineers, which is a primer national society for industrial engineering. There is only one winner annually.

Associate Professor **Josep Jornet**, electrical and computer engineering, was awarded a $900K National Science Foundation grant, in collaboration with Rice University and Brown University, for "Scaling WLANs to TB/sec: THz Spectrum, Architectures, and Control." The project will develop new communication solutions to scale up the capacity of wireless networks to Terabits per second (a trillion of bits per second). He also published a paper in the prestigious journal *Science*, titled: "Tunable Topological Charge Vortex Microlaser."

University Distinguished Professor **Dagmar Sternad**, jointly appointed in biology, and electrical and computer engineering, was selected for the Fulbright Award for the academic year 2021-2022 to work on "Variability and Redundancy in Motor Learning" at the Santa Lucia Foundation at the University of Rome Tor Vergata, Italy.

Assistant Professor **Sidi A. Bencherif**, chemical engineering, and his team published their work on "Engineering a macroporous fibrin-based sequential interpenetrating polymer network for dermal tissue engineering" in *Biomaterials Science*

as part of the themed collection: Biomaterials Science Emerging Investigators 2021, which gathers the very best work from biomaterials scientists in the early stages of their independent careers. Additionally, Bencherif was named one of the 2021 Rising Stars by the Cellular and Molecular Bioengineering (CMBE) Special Interest Group (SIG) within the Biomedical Engineering Society (BMES).

Professor **Edmund Yeh**, electrical and computer engineering, was awarded an $875K two-year National Science Foundation grant, titled "CC* Integration-Large: N-DISE: NDN for Data Intensive Science Experiments." Northeastern is leading the multi-university research initiative, in collaboration with California Institute of Technology, the University of California at Los Angeles, and Tennessee Technological University. The N-DISE project aims to accelerate the pace of breakthroughs and innovations in some of the world's most impactful and data-intensive science fields such as the Large Hadron Collider (LHC) high energy physics program and the BioGenome and human genome projects.

Professors **Mario Sznaier** and **Octavia Camps**, electrical and computer engineering, were awarded an $880K National Science Foundation grant for "Safe Learning-Enabled Cyber-Physical Systems." In spite of tremendous advances in machine learning, the goal of designing truly autonomous cyber-physical systems (CPS) capable of learning from and interacting with the environment to achieve complex specifications remains elusive. The research project will address this by developing a new class of verifiable safe learning-enabled CPS, capable of adapting to previously unseen dynamic scenarios where the data is generated, and decisions must be made, as the system operates.

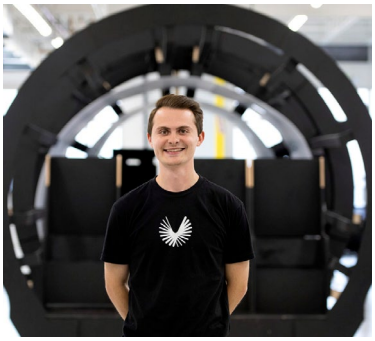
Professor **Ozlem Ergun**, mechanical and industrial engineering, was named a 2021 Franz Edelman Laureate for authoring the Edelman finalist paper in *INFORMS Journal on Applied Analytics*. Laureates are recognized for their significant contribution to work that is selected as representative of the best applications of analytical decision making in the world.

STUDENT NEWS

Selected Highlights

National Science Foundation Graduate Research Fellowship Student and Alumni Award Recipients

Michael Ben Eck, PhD'24, civil engineering
Sydney Anne Morris, E'21, chemical engineering
Nicholas Roy O'Hare, PhD'24, chemical engineering
Diego Felipe Rivera, E'21, mechanical engineering
Rachel Lauren Shapiro, E'17, chemical engineering
Nathaniel James Silvia, PhD'24, bioengineering
Evan Zachary Toth, E'21, chemical engineering
Erica Kristen Wagner, E'20, bioengineering



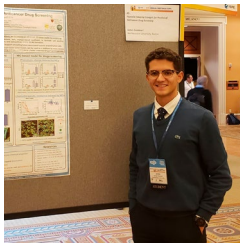
Industrial engineering student **Alex Bender**, E'20, was named as a finalist of the 2020 INFORMS Undergraduate Operations Research Prize for his paper titled "Estimating Effectiveness of Identifying Human Trafficking Victims: An Application of Data Envelopment Analysis on the Nepal–India Border."

The **Society of Women Engineers** (SWE) student group received two 2020 Society of Women Engineers Mission Awards: Collegiate Gold, and Best Practice–Membership Retention & Engagement. The Gold award is the highest overall award level for the new SWE Mission Award structure and recognizes our section's commitment to SWE's Core Values and Strategic Goals based on results from our activities across 10 categories.

Beth DiBiase, E'21, chemical engineering and biochemistry, received the 2019-2020 Donald F. & Mildred Topp Othmer Scholarship Award. This honor is given to 15 AIChE students annually for their outstanding academic achievement and involvement in student chapter activities.

Tyler Gogal, E'21, mechanical engineering, received a Fulbright Open Study/Research Award to pursue a master's degree in environmental engineering with a focus in water resources from the University of Iceland.

A 2020 **civil and environmental engineering capstone team** placed second in the International Water Environment Federation Student Design Competition in the Environment Competition for their project: Rock Meadow Parking Lot and Stormwater Design. There were 28 participating schools, representing 22 member associations and five countries. Students include **Sam Kinnaly**, **Kate Engler**, **Annie Lamonte**, and **Emma Totsubo**.



Chemical Engineering student **James Sinoimeri**, E'21, was selected for the Future Leaders in Chemical Engineering Symposium organized by North Carolina State University. Sinoimeri was invited to present his research on the use of Hypoxia-Inducing Cryogels for Preclinical Anticancer Drug Screening, which was performed under the supervision and guidance of Assistant Professor **Sidi A. Bencherif**.

Spencer Lake Jacobs-Skolik, E'22, electrical engineering, and **Cameron Young**, E'22, chemical engineering and biochemistry, received the 2021 Barry Goldwater Scholarship, the most distinguished award given to undergraduate scientists and engineers. It is a highly competitive, merit-based award for outstanding students in mathematics, the natural sciences, and engineering who are interested in pursuing careers in research.

Louiza Wise, E'21, environmental engineering, received Northeastern's COMPASS Award. The award recognizes outstanding seniors who, during their time on campus, have demonstrated a true commitment to a core set of values: leadership, volunteerism, academic integrity, and commitment to Northeastern.

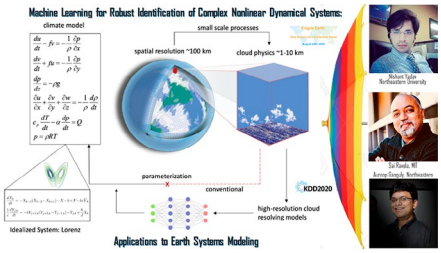
Kerry Eller, E'21, bioengineering, received the Harold D. Hodgkinson Achievement Award for her distinguished scholastic achievement as well as character, personality, qualities of leadership, cooperative work experience, and service in voluntary organizations and activities.

Students Cailey Denoncourt, E'23, bioengineering, and **Liza Russell**, E'23, mechanical engineering, received the Student Paper Award for their paper, "Navigating and Energy Generating Insole: Vibrating Walking Directions" at the ASEE 2020 Virtual Conference.

Criss (Xiaoyu) Zhang, PhD'22, mechanical engineering, served on the program committee and helped run the 2020 Around-the-Clock Around-the-Globe (AtC-AtG) Magnetics Conference, a new virtual international conference powered by the IEEE Magnetics Society.

Siyue Wang, PhD'22, computer engineering, won first place for Best Presentation in the Fourth Workshop for Women in Hardware and Systems Security (WISE 2020). She presented her recent work on "Intrinsic Examples: Robust Fingerprinting of Deep Neural Networks" with her advisor, Assistant Professor Xue "Shelley" Lin.

Vageeswar Rajaram, PhD'21. electrical engineering, received Best Paper Award at the IEEE IFCS-ISAF 2020 Virtual Conference for his paper "A Zero Standby Power MEMS Switch-based Infrared Sensor with Frequency Output."



Nishant Yadav, PhD'23, interdisciplinary engineering, won the Best Student Paper Award by the AI Foundation for Good's Fragile Earth Workshop for his paper "Machine Learning for Robust Identifpcation of Complex Nonlinear Dynamical Systems: Applications to Earth Systems Modeling."

DEAR ALUMNI AND FRIENDS,

In 2020, the College of Engineering addressed the pandemic with resilience and innovation. Hybrid NUflex gave students the opportunity to learn online and in person. Co-op programs brought new meaning to "experiential learning" as they adapted and evolved in the face of unprecedented circumstances, ensuring they remain the cornerstone of a Northeastern education. Research labs began work on new challenges rising from the pandemic, with Northeastern leading the charge in response efforts, receiving more National Science Foundation rapid response grants than any university without a medical school.

Through it all, we had you: our alumni, our donors, our friends. Thank you for stepping up to support our community at a time when it matters most.

It's a community that together can achieve great things. COVID-19 has been a new and unexpected hurdle, but you met the call, helping us develop new initiatives and programs and supporting students in need. COE engineers are problem-solvers. With your aid, our faculty have been instrumental in research efforts such as fabric effectiveness in protective masks and sewage monitoring systems for COVID-19 detection, as well as the development of gas sensors for COVID-19 diagnosis, and robotic technology for testing medical protective gear equipment. Our students were able to work on situation-relevant projects such as the creation of UV light sanitizing robots for desks and table-tops, and replicated classroom conditions with take-home lab kits.

The following pages offer only a snapshot of the many ways you have helped empower the College of Engineering. Whether it's through your continued annual support, a gift to one of our relief funds, the creation of a new endowed fund, the facilitation of corporate support, or more, thank you for your generosity and tireless dedication. We're so glad we've been able to keep in touch with you through it all, with our new virtual capabilities–and we look forward to seeing you in person and online in the months ahead.

Until then, feel free to reach out to us via phone, web, email, and video/meeting conferencing. You can also visit us anytime at:

Giving website: giving.northeastern.edu/explore-funds/engineering

Development Team Contacts: coe.northeastern.edu/alumni/development-team/

With appreciation,

The COE Development Team

photo by Tom Spierto

FROM LEFT TO RIGHT (BACK ROW):
MIKE BOORAS
EVA ROSENN
LAURIE BOWATER

FROM LEFT TO RIGHT (FRONT ROW):
JIM NGUYEN
SARAH BATISTA-PEREIRA
ELIZABETH SANICOLA
KIT MCCARTHY

John Nelson, E'66, mechanical engineering, MBA'78, with his grandchildren, Emma and Owen.

A LEGACY THAT LIVES ON

THE COLLEGE OF ENGINEERING was sad to learn of the recent passing of alumnus **John R. Nelson**. He will be remembered for his scientific achievements during a nearly 40-year career and also his commitment to philanthropy, including a recently endowed engineering scholarship fund at Northeastern.

John grew up on Fairview Street in the Roslindale neighborhood of Boston. One of nine children and the son of a Boston Police Department patrolman, he loved building and fixing things and was destined for an engineering career–but funds for college were limited. At the time, Northeastern's co-op program offered the perfect means for John to finance his education. He graduated in 1966 with a Bachelor of Science in Mechanical Engineering, and then earned an MBA in 1978 from Northeastern's D'Amore-McKim School of Business.

John's decision to attend Northeastern charted the course for his own life, but it also began a tradition that now spans three generations. John's younger brother, George, graduated in 1971 with a BS in Business Administration (BSBA) and a focus on accounting. In 1990, John's son, Chris, also earned a BSBA toward a career in marketing and, in 1992, his son, Scott, graduated with a BS in Civil Engineering. And two months before he died, John learned that his grandson, Owen, would attend Northeastern to study architecture and design. He was delighted. "We Huskies have to stick together," he said.

A far-reaching scientific impact

After graduation, John worked as an engineer at Itek and Cognos, two Boston-area companies that developed optics for defense and aerospace applications.

In 1976, John joined Waters Corporation, an analytical instrumentation company headquartered in Milford, Massachusetts. He found his professional home there, embarking on a 30-year career that included serving as Vice President of Research and Development, and eventually Executive Vice President and Chief Technology Officer. While at Waters, he led the development of cutting-edge hardware and software that supported the emergence of biomedical, life science, and pharmaceutical innovations.

John was recognized by NASA for his contributions to the Viking 76 Lander, which touched down on Mars in July 1976. His contributions included hardware development, fabrication, and testing for the camera system. "Few people are able to leave a legacy on another planet," says his son Chris. "And my Dad would've been pleased by the coincidence of the Perseverance Rover landing on Mars on February 18, just minutes after his wake started."

A spirit of giving and discovery

John also made an enormous and lasting impact here on Earth. The recently established Nelson Family 1966 Scholarship at Northeastern will help undergraduates in the College of Engineering finance their education.

"My Dad traveled the world, rafting in the Colorado River through the Grand Canyon, kayaking Alaskan inlets, exploring African savannahs and riding a hot-air balloon over the Serengeti at sunrise," Chris recounts. "But he never forgot his roots and how he'd struggled to fund his own college education. He created the Nelson '66 Scholarship to help others achieve their own dreams."

John's philanthropy didn't end there. Together with his late wife Judy, they established a Foundation with 25+ years of major gifts to benefit the Make-a-Wish Foundation, Boston Children's Hospital, the Boston Museum of Science, and St. Jude's. "He was a Cub Scout den leader, youth hockey coach, and my algebra tutor. A loving son, brother, husband, father and grandfather, he was always thinking of others," Chris explains. "He will be greatly missed, but we're incredibly proud of the vast contributions he made during his lifetime."

A Pledge of Support

A range of philanthropic efforts are helping to increase engineering diversity at Northeastern—and in the global workforce

WHILE 2020 WAS A CHALLENGING year, it did result in some positive impacts. Among these was an increased awareness of systemic racial inequalities in the U.S., which led many businesses and private individuals to commit to supporting social change.

"In asking 'What can we do to help correct this situation?', I think many people began to recognize that access to educational opportunities plays a critical role," says **Richard Harris**, assistant dean and director of the Northeastern University Program in Multicultural Engineering (NUPRIME) and special advisor for Educational Pathway Programs in the Office of the Provost.

While Northeastern's College of Engineering is ahead of national averages in terms of minority representation and retention—and the NUPRIME effort to recruit and mentor minority students dates back to 1974—the college recognizes that there is much to be done.

A range of committed donors are partnering with Northeastern to diversify not only today's engineering student body, but eventually the global engineering workforce as these students graduate.

Called to action

Among those watching the Black Lives Matter protests in 2020 and wondering "What can we do?" were executives and associates at DN Tanks, a company in Wakefield, Massachusetts which specializes in the design and construction of concrete water storage tanks. The company, which has provided co-op opportunities for Northeastern engineering students for over 45 years, quickly convened employee focus groups.

"We recognize we can't single-handedly change the world, but we wanted to do something that would make a positive impact," explains **Charlie Crowley**, former CEO and current Chair of DN Tanks. "We wanted the effort to be driven by employees, so we asked them to brainstorm ideas for increasing diversity in our company and the civil engineering workforce in general."

Given the company's long relationship with Northeastern's College of Engineering, the employees' response included creating an endowment at Northeastern. Less than a year later, the DN Tanks Fund for Educational Equity in Civil & Environmental Engineering is supporting ongoing scholarships for minority students at Northeastern.

Ed Holmes, E'87, is DN Tanks' director of technical training and manages the co-op program in the Wakefield office. He notes that the company's goal was to begin making a difference immediately. "Since an endowment takes time to generate dividends, we plan on supplementing the initial donation with additional funds so we can get the scholarship up and running immediately," remarks Holmes. The DN Tanks Fund provides tuition support for a second-year or above civil and environmental engineering student.

Environmental Partners (EP), a multidisciplinary engineering and consulting firm in Quincy, Massachusetts, has promoted diversity in its workforce since its inception in 1997. While women represent approximately 50% of EP's engineering workforce, far higher than the national average of 13%, the firm has been challenged to hire minority engineers. According to **Ryan Trahan**, E'02, chief operating officer at EP, this has been a long-term issue for the entire architecture, engineering, and construction (AEC) community.

"The AEC industry has historically struggled with diversity and inclusion. While I believe there is more work to be done, we've actually seen great progress in gender inclusivity over the last 20 years, as more women pursue STEM careers. What's particularly alarming is how underrepresented minorities are in our fields," says Trahan. "As a company, we asked, 'How can we encourage diversity and create greater opportunities?'"

Today EP is funding an annual scholarship for a student in their

"We wanted to give back specifically to Northeastern students, as they've added so much value to EP as co-op students and employees."

Ryan Trahan, E'02
COO of Environmental Partners

second year or higher at Northeastern pursuing a career in civil, environmental, or transportation engineering. Awardees must identify as historically underrepresented in engineering, specifically Black/African-American, Latinx/Hispanic-American, and Native/American Indian.

"We wanted to give back specifically to Northeastern students, as they've added so much value to EP as co-op students and employees," states Trahan. "In fact, Northeastern graduates make up about one-third of our engineering staff. While we acknowledge that this is one small piece of a very complex puzzle, we're fortunate that we have the means to do something, and we're excited to help create a more diverse pipeline of students and graduates of the Northeastern College of Engineering."

Jean Inoa, E'21, received the first Environmental Partners Scholarship. "As a first-generation student from a low-income family of immigrants, I can't stress enough the gratitude I have," says Inoa. "By receiving this scholarship, I will be able to fully dedicate myself to being a student, rather than working to sustain myself."

It takes a village

Other support made possible through gifts for historically underrepresented students in the College of Engineering include, but are not limited to:

- **The Black Engineering Scholarship** provides need-based aid to minority engineering students chosen by the College of Engineering Dean's Office via a nomination process.
- **The Dr. Winslow L. Sargeant Engineering Scholarship** provides support to one or more African-American students majoring in engineering who are involved in entrepreneurial activities.
- **The National Action Council for Minorities in Engineering (NACME)** grants annual scholarships to 25 Northeastern engineering students from historically underrepresented populations.
- **The Society for Hispanic Professionals and Engineers** offers scholarship opportunities to members of the Northeastern chapter.
- **The National Society of Black Engineers** offers scholarship opportunities to members of the Northeastern chapter.

Harris notes that individual donors can also make an enormous impact in fostering inclusion. "The Faith Leahy Scholarship was created in the 1970s by a forward-looking woman who recognized the racial disparity in engineering before many others," Harris says. "We've recently removed some geographic limitations on this fund, and it will be open to many more underrepresented students in the 2021-22 academic year."

Harris points out that **Dr. Winslow Sargeant**, E'86, has acted as both a hands-on mentor to Northeastern's minority students and a powerful fundraising force. Not only has he established his own scholarship fund, he helped endow the Black Engineering Scholarship, and has encouraged other alumni to support the College of Engineering's efforts to diversify.

Latonya Beverly, E'19, received financial support from both the Dr. Winslow Sargeant and Black Engineering Scholarship Funds. She recognizes the value of "paying it forward."

"Dean Harris once said to me, 'It is not about me, but those who came before and those who will come after.' This statement has really made an impact on my perspective on life and I have really adopted this outlook for myself," notes Beverly. "It means a lot to know that there is a village looking out for me, reaching back as I climb."

DN Tanks' Crowley emphasizes that students are not the only beneficiaries from the ongoing efforts to diversify the global engineering workforce. "Engineers solve problems," he says, "and the more diverse our perspectives—from a racial standpoint, from a gender standpoint, from a geographic standpoint—the more creative our solutions will be. We will all benefit from making the engineering workforce more diverse and more innovative. It's not only the right thing to do, it's the smart thing to do."

"We will all benefit from making the engineering workforce more diverse and more innovative. It's not only the right thing to do, it's the smart thing to do."

Charlie Crowley
Chair of DN Tanks

SPOTLIGHT ON PHILANTHROPY

Contributing to a Plant-Based and Climate-Friendly World

Plant Shift Initiative

Jane Patterson and **Sebastiano Cossia Castiglioni**, who are parents of Northeastern student **Orlando Cossia Castiglioni**, E'23, mechanical engineering, have combined their professions in design and business with their passion for animal welfare and an animal-free food supply. Their recent gift to the College of Engineering will help establish two co-op positions in the Sherman Center for Engineering Entrepreneurship Education focused on plant-based and climate-friendly food systems. We spoke to them about the Plant Shift Initiative, and their hope that their gift will inspire innovative solutions to a critical issue facing our planet.

CAN YOU BRIEFLY DESCRIBE THE PLANT SHIFT INITIATIVE?

The goal of the Plant Shift Initiative is to nurture tomorrow's entrepreneurs and leaders through the development of projects that tackle animal welfare and climate change issues with creative "plant-based" ideas. By plant-based, we mean all ingredients, products, technologies, and materials that remove animals from the food system and from all other productions and activities. We hope that the initiative will awaken students, faculty, and administrators to the enormous opportunity and long-term benefits of an ethical, plant-based approach to the world's greatest challenges.

Meat production is the direct leading cause of global deforestation. Industrial fishing has brought the majority of sea species to the brink of extinction, while over 50 percent of plastic in the ocean is abandoned fishing gear. Antibiotic resistance is possibly the greatest danger humanity will face in the future because of animal factory farming. The intrinsic inefficiencies of the animal-based food system are deep and unresolvable. The quickest and most efficient way to curb climate change—which also brings the added benefits of reducing animal cruelty and being beneficial for human health—is the shift to a plant-based diet.

As an example, the development of alternative proteins ('alt proteins')—although already advanced—is an entire field where more innovation, creativity, and technical solutions will further facilitate the replacement of animal products with excellent alternatives. Engineering is essential to making progress in this exciting space. A Plant Shift Initiative at a leading university like Northeastern could be a model that sparks breakthroughs and inspires others to follow suit.

WHAT INSPIRED YOU TO PROVIDE THIS GIFT TO THE UNIVERSITY?

We admire the team spirit, maturity, and kindness that distinguishes Northeastern students. They are constantly giving to each other—giving their time, their help, their ideas, and their resources. This 'giving' ethos was the main inspiration for our gift. We hope to positively impact the lives of exceptional human beings, while championing an effort that is essential for the future of the planet.

WHY IS THE PLANT SHIFT INITIATIVE IMPORTANT TO YOU AND YOUR FAMILY?

As animal advocates, environmentalists, and disruptive entrepreneurs, we see the urgency to prepare students to lead the world they are inheriting in the right direction. Finding people to hire who are aligned to, or even aware of, the plant-based way of thinking remains a challenge, despite the fact that this is a booming industry in need of young minds and new ideas. The obvious solution is to support academia to help fill this gap. Graduates with a deeply rooted plant-based outlook are highly sought after in a wide array of professions today. This trend is only going to grow, as plant-based and climate-friendly solutions race to the forefront of innovation in food, materials, energy and all other human activities.

WHAT DO YOU HOPE TO ACHIEVE THROUGH YOUR GIFT TO NORTHEASTERN?

The Plant Shift Initiative fund has the potential to help stimulate new ideas and directions and improve one's experience at Northeastern. The university could start developing game-changing ingredients or technologies. Certainly any project that leads a student to discoveries, crafting a thought-inspiring documentary, launching a start-up, aspiring to an altruistic political career, striving to reduce animal cruelty, helping curb climate change, or developing a groundbreaking scientific study, would have great positive impact and benefits that cannot yet be measured.

To further engage the Northeastern community, we plan to launch a speaker series on a variety of topics, such as how plant-based strategies for nature conservation, energy, transportation, agriculture, entrepreneurship, design, business, and food tech can benefit climate correction. Events can be found at alumni.northeastern.edu/events.

Plant Shift Initiative Fund

He's traveled the world, from the North Pole to Antarctica—and still dreams of landing on the Moon.

In 1956, during one of Ken Bronstein's first engineering classes at Northeastern, a professor made predictions about what might change by the year 2000. The Space Race was on, and personal jet packs and regular trips to the Moon were a couple of the possibilities that sparked Bronstein's imagination. He dreamed of embarking on a lunar journey, and today, he's disappointed that technology hasn't made it a reality for himself or many others—but other travels awaited him.

Raised in a family of small business owners, Bronstein, E'61, decided he would be the first to attend college. His father told him he didn't need to earn a degree because he could learn from family businesses and "the school of hard knocks," Bronstein says. But he wanted to explore the larger world, and his mother encouraged him. Interested in technology and engineering, he applied to Northeastern's industrial engineering program, which gave him broad experience in electrical, mechanical, and civil engineering, as well as law and business.

Bronstein attended Northeastern for another reason that many of today's students choose it: co-op. "The value of co-op was in the experience it gave me at different companies," he says. He looked for co-ops at small, medium, and large businesses to help understand how different-sized organizations functioned.

After that co-op experience, he wrote a paper on the emerging field of semi-conductors. The paper was shared by one of his professors with IBM, which led to a job offer. Bronstein spent a satisfying and varied career at IBM in New York City for 37 years, interrupted by two years of service in the Army.

"At IBM, we were changing the world. We made contributions to it," Bronstein says with pride. "Northeastern is very important to me because it started me on my career in engineering and business."

Active in his retirement, Bronstein has a unique hobby: He loves all things related to firefighting and fire departments, and his collection of helmets fills a wall in his home. A vintage 1931 Aherns-Fox Fire Engine is kept safely in a barn and is the envy of other collectors. He's even an honorary fire chief in New York City, where he resides. Bronstein travels extensively around the world and visits local fire stations wherever he goes, which has given him a global network of firehouse acquaintances.

When considering his estate plans, Bronstein is interested in organizations where people help people and he's named several in his will, including Northeastern. The university was integral to his preparation for his life and career, and his gift will support the industrial engineering program, which he credits as "the foundation, the base of where I am today."

Bronstein's advice to students is simple and direct. "Don't take the easy jobs! Choose ones that will challenge you," he counsels. "Make your mistakes in your co-op job—not in the job after you graduate!"

Northeastern University
Gift Planning

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giftplanning@northeastern.edu
Learn more about Ken and other legacy donors at plannedgiving.northeastern.edu

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photo by Matthew Madoono

Hybrid NUflex technology and world-class on-campus testing capabilities have provided a safe and flexible learning environment for students during the pandemic. Also, our faculty quickly pivoted their research over the past year, receiving 10 National Science Foundation RAPID grants for COVID-related research.