McCormick School of Engineering and Applied Science

NORTHWESTERN ENGINEERING

FALL 2018

WATER IN CRISIS

CONFRONTING THE GLOBAL ISSUE OF WATER INSECURITY. COLLABORATING TO FIND SOLUTIONS.

CREATIVE SPARK

In June, an Evanston campus parking lot transformed into an industrial scene as an Iron Pour event capped off a new course, “Leonardo, Geometry, and the Art of Manufacturing.” Offered by the Segal Design Institute, the class encouraged its 10 students to understand the historical, artistic, and theoretical underpinnings of everyday forms and processes. The goal: “To honor the makers who have come before us and those we are trying to be,” says Matthew Cummins, an adjunct lecturer who co-taught the class with David Gatchell, director of the Manufacturing and Design Engineering (MaDE) program.

Photograph by Rob Hart

"Engineering touches every part of campus and our lives, and our alumni go on to make a difference in fields as varied as artificial intelligence to medical devices. It is an exciting time to be an engineer."

GREETINGS FROM NORTHWESTERN ENGINEERING

Lately, headlines cry out problems regarding water: too much in places like Florida, North Carolina, and Puerto Rico after destructive hurricanes; too little in places like South Africa, Israel, and Northern California after devastating droughts. Never has it been so critical to study the vital fluid that sustains all life.

With our work at the Center for Water Research, faculty are designing, simulating, and integrating innovative materials and engineered bioprocesses into water systems. Led by Aaron Packman, professor of civil and environmental engineering, our researchers collaborate with others from a variety of disciplines across Northwestern, a mindset so typical at our University and so necessary to solve such a complex issue.

As you will read in this issue, other McCormick researchers are thinking beyond this planet. An interdisciplinary team is looking to improve life on Mars—human life, that is. Led by Associate Professor Gianluca Cusatis, the group created "Marscrete," a concrete developed from native materials in the Martian landscape which could be used to build homes with 3D printing technology on the Red Planet. Already, the work has received kudos from NASA. As with many technologies developed for NASA initiatives, think of the Gemini and Moon missions, I suspect that many of these new ideas may find applications here at home.

This type of work inspires our students to aim for ever more ambitious targets. That is very clear at Design for America (DFA), the Northwestern-based national network that addresses community-based challenges using the human-centered design process. This fall, DFA earned the prestigious National Design Award for Corporate and Institutional Achievement from the Cooper Hewitt, Smithsonian Design Museum. This honor puts DFA in the good company of previous winners, including Apple, Etsy, and TED. We could not be prouder.

The breadth of work at Northwestern Engineering continues to grow. You can see it in other stories in this issue, ranging from teaching high school students the concepts of synthetic biology to collaborations with psychology to study personality types. Engineering touches every part of campus and our lives, and our alumni go on to make a difference in fields as varied as artificial intelligence to medical devices. It is an exciting time to be an engineer.

As always, I welcome your feedback.

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

On the Cover Two PhD candidates check a water level sensor at Gensburg-Markham Prairie, working to understand how the prairie responds to major rainfall events under a changing climate.

Photograph by Alex Garcia

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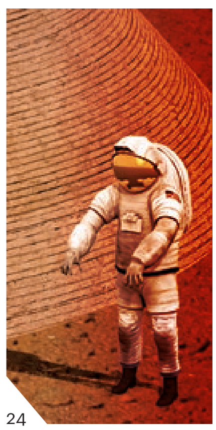
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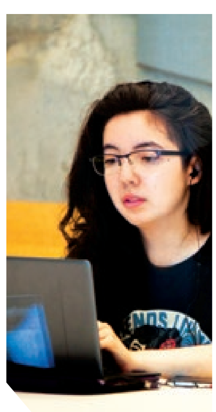
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NORTHWESTERN ENGINEERING
FALL 2018

NEWS

New Center for Advanced Regenerative Engineering Launches

Northwestern's Center for Advanced Regenerative Engineering (CARE) officially launched this past spring with a bold mission and interdisciplinary mindset.

The Center aims to create an ecosystem that enables researchers and clinicians to regenerate tissues and organs for adult and pediatric patients. That effort began with CARE's inaugural event, the Symposium on Regenerative Engineering, hosted at Chicago's Prentice Women's Hospital in May.

"This event brought together people of significantly different backgrounds to understand the type of transdisciplinary collaborations and enterprise that are necessary to move the field of regenerative engineering forward," says Guillermo Ameer, CARE's founding director and Daniel Hale Williams Professor of Biomedical Engineering and Surgery at Northwestern.

The Center has two immediate goals: 1) to develop distributable, easy-to-use tools capable of regenerating tissues and organs, specifically prioritizing the needs of surgeons and patients; and 2) to construct and support a collaborative ecosystem for clinical implementation of regenerative technology.

CARE will also educate and train entrepreneurs and researchers skilled in regenerative engineering. Among its plans for accomplishing this are fellowships, internships, sabbaticals, and a regenerative engineering club for students.

TEAM WINS CLEAN ENERGY PRIZE AT RICE BUSINESS PLAN COMPETITION

Northwestern Engineering student startup NUMiX captured the US Department of Energy's Cleantech University Prize (Cleantech UP) at the 2018 Rice Business Plan Competition in April. The $50,000 award will provide the team with funding for business development, commercialization training, and other educational opportunities.

NUMiX launched earlier this year in the Farley Center for Entrepreneurship and Innovation's NUvention: Energy course. NUMiX's business includes a suite of sorbent powder products capable of collecting metals from water. Such products could be used to clean toxic metals out of industrial wastewater or recover silver in manufacturing processes for reuse.

"It was a surreal experience to win the Cleantech Prize and a wonderful validation of the innovative technology we're working to bring to market."

KATIE KOLLHOFF NUMiX CEO, STUDENT IN MASTER OF ENGINEERING MANAGEMENT (MEM) PROGRAM

200

Number of attendees at the inaugural Central US Synthetic Biology Workshop

47

Number of Northwestern students who attended the annual Grace Hopper Celebration, the world's largest gathering of women technologists

MICROGRIDS SYMPOSIUM EXPLORES RENEWABLE ENERGY FOR SUSTAINABLE DEVELOPMENT

In April, experts from academia, government, and industry gathered at Northwestern for the Symposium on Microgrids: Renewable Energy Microgrids for Sustainable Development. The event examined the role of microgrids in natural disasters, such as Hurricane Maria, and how to satisfy global power needs.

Northwestern Engineering's Eric Masanet delivered the opening talk in which he discussed microgrid opportunities in sub-Saharan Africa and Southeast Asia.

"These are the regions in greatest need of technological progress and energy access," Masanet says. "Renewable microgrids could be one solution that helps us decouple growth from CO_2 emissions."

Music and Engineering Harmonize

Shane Choi has a passion for music and a mind for engineering, something he paired together as a dual-degree mechanical engineering and trumpet performance major at Northwestern. Now a master's degree student studying mechanical engineering, he unites the two in a more tangible way by converting discarded musical instruments into artistic and functional household lamps.

Choi's effort began in late 2016 when he purchased a rickety cornet online. After realizing the cornet could not be restored into playing condition, Choi began contemplating other uses for the antique-looking instrument. When he saw images of lamps crafted from recycled goods, Choi found his inspiration.

Working in his family's garage, Choi taught himself soldering and wiring basics and incorporated the trumpet valves into the design by lathing off the valve sections so that they would both compress and accommodate wiring. He then routed a power switch into the lamp wires before press-fitting the wired button into the valve casing.

Choi has created and sold about a dozen lamps. Initially, he dedicated profits from each sale to local music teachers so they could purchase instruments for students and provide lessons. He also earmarked proceeds directly for individual students to fund music camps or projects. More recently, Choi teamed up with Simple Gifts, a Northwestern-based startup connecting underprivileged youth to musical instruments.

NORTHWESTERN RECEIVES $15 MILLION FOR DEPARTMENT OF ENERGY FRONTIER RESEARCH CENTERS

Northwestern University research initiatives have received a cumulative $15 million from the US Department of Energy for the most recent funding round of the national Energy Frontier Research Centers program. The two selected proposals from Northwestern, the Center for Bio-Inspired Energy Science and the Center for Light Energy Activated Redox Processes, were among 42 programs collectively funded at $100 million to accelerate scientific understanding in energy-relevant fields. Both CBES and LEAP are part of Northwestern's ecosystem of 53 University Research Institutes and Centers.

$3.6 MILLION

Amount awarded by the US Department of Energy to support creating better qubits, the smallest unit of a quantum computer

Autonomous Robots Use Speed, GPS Tracking at 2018 Design Competition

A student-designed, autonomous robot named VeggieButt took down the competition to win Find that Block!, Northwestern's 27th annual Design Competition. In a demonstration of speed and agility, VeggieButt bested second-place Team Phoenix for the $1,000 award.

At the competition held in May at the Ford Motor Company Engineering Design Center, robots were randomly assigned to look for either steel cubes or cylinders scattered throughout the arena. Once found, the objects were brought back to areas marked with a circle or square. For every cube or cylinder correctly placed on the corresponding shape, the team earned a point. A round-robin tournament followed by a direct elimination bracket determined the winner.

Eight teams of undergraduates from a variety of engineering fields spent five months designing, building, and programming their robots. Many of this year's machines used GPS location tracking borrowed from the HTC VIVE virtual reality system. The feature afforded each robot acute spatial awareness, which made for more directed searches and exciting head-to-head battles. A team called Bananas received the $500 Myke Minbiole Elegant Engineering Award.

STUDENT GROUP INNOVATES FOR SOCIAL CHANGE

After Conor McGeehan got a taste of using technology and computer science for social good in his coursework, he wanted to do more. "A lot of my friends and classmates in computer science courses felt like they weren't doing anything outside of their studies that made an impact on the community," says McGeehan, a Northwestern Engineering junior studying technological entrepreneurship.

McGeehan's drive to do good was sparked in Design Thinking and Communication, a two-quarter course required for all first-year engineering majors. In fall 2017, he founded Develop + Innovate for Social Change, DISC NU for short, a group of undergraduate students aiming to use their skills to help social impact-oriented groups in the Chicago community. The group's ambitions include creating websites for nonprofits and developing ways to make nonprofits' research data available to the public.

"We learned a lot about working in intense circumstances on something that is way bigger than ourselves."

JULIE MALEWICZ JUNIOR PHYSICS MAJOR

HACKING TO HELP RED CROSS RELIEF EFFORTS

Six months after Hurricane Maria devastated Puerto Rico, students in a Northwestern Engineering class developed solutions to help the American Red Cross optimize relief efforts. During a 48-hour hackathon, interdisciplinary student teams in McCormick's IEMS 365: Analytics for Social Good course developed hands-on solutions using data analytics to aid humanitarian efforts in a natural disaster.

The class, taught by Professor Karen Smilowitz, exposes students to the challenges and opportunities of applying data analytics to achieve social good. The open-ended assignment—to help the Red Cross develop new and better ways of handling their response to hurricanes—served as the final project for the class, which includes juniors and seniors from any major across Northwestern.

GRADUATE STUDENTS CELEBRATE 160TH COMMENCEMENT

Northwestern's McCormick School of Engineering celebrated the graduation of 780 master's degree and 190 PhD candidates in June as part of the University's 160th Commencement.

Priscilla Lu (PhD '80), Asia head of the Sustainable Investments group at Deutsche Bank's DWS, gave the address at the PhD Hooding Ceremony. Ted Karwoski (MS '81), entrepreneur and developer of many biomedical products, spoke at the Master's Degree Recognition Ceremony, and Edward Chen ('93, MEM '98), CEO and founder of Biometrics4ALL, addressed McCormick's professional master's program.

$7.5 MILLION

Amount granted for Center for Innovation in Point-of-Care Technologies for HIV/AIDS at Northwestern University (C-THAN)

32

Number of universities represented at the Design for America Leadership Studio

MARATHON OPTIMIZATION TOOL WINS BUSINESS ANALYTICS PRIZE

Using a range of analytics tools, a team led by Northwestern Engineering's Karen Smilowitz is enhancing current best practices for resource management set by the Chicago Marathon. The Situational Awareness for Events system—known as SAFE—incorporates critical data into one user-friendly dashboard to provide leaders of large-scale events like marathons a centralized information source.

At the 2018 INFORMS Conference on Business Analytics and Operations Research, they bested competitors from IBM, Macy's, and other corporate enterprises to capture the Innovative Applications in Analytics Award.

"IT'S EXCITING TO RECEIVE RECOGNITION FOR THIS COLLABORATIVE EFFORT THAT HELPS RACE DIRECTORS DO THEIR WORK MORE EFFECTIVELY FROM BOTH A PUBLIC SAFETY AND EVENT PLANNING PERSPECTIVE."

KAREN SMILOWITZ

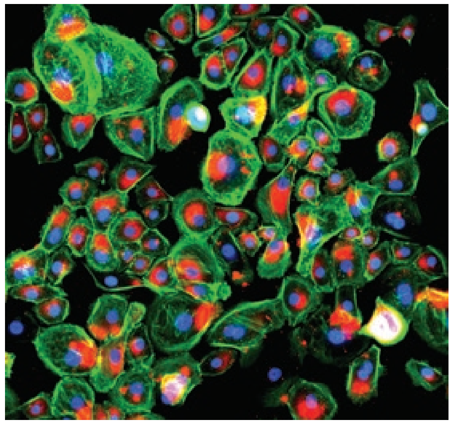
JAMES N. AND MARGIE M. KREBS PROFESSOR IN INDUSTRIAL ENGINEERING AND MANAGEMENT SCIENCES

MCCORMICK UNDERGRADUATE CLASS OF 2018 CELEBRATES 160TH COMMENCEMENT

Northwestern's McCormick School of Engineering celebrated its undergraduate Class of 2018 in June as part of the University's 160th Commencement.

Graduates from all disciplines in regalia and plastic ponchos gathered at a rainy Ryan Field on Friday, June 22, for the main commencement ceremony. World-renowned soprano Renée Fleming delivered the address. The following day, more than 400 McCormick students returned to Ryan Field for the School's Undergraduate Convocation. Daryl Morey ('96), general manager of the Houston Rockets, delivered the keynote speech. Dean Julio M. Ottino reminded the graduates to remember they have gained advantages during their Northwestern career.

LAB NOTES



"WITH THIS NEWER APPROACH, WE'RE NOT RELEASING DRUGS OR OUTSIDE FACTORS TO ACCELERATE HEALING. AND IT WORKS VERY WELL."

GUILLERMO AMEER
DANIEL HALE WILLIAMS PROFESSOR OF BIOMEDICAL ENGINEERING AND SURGERY

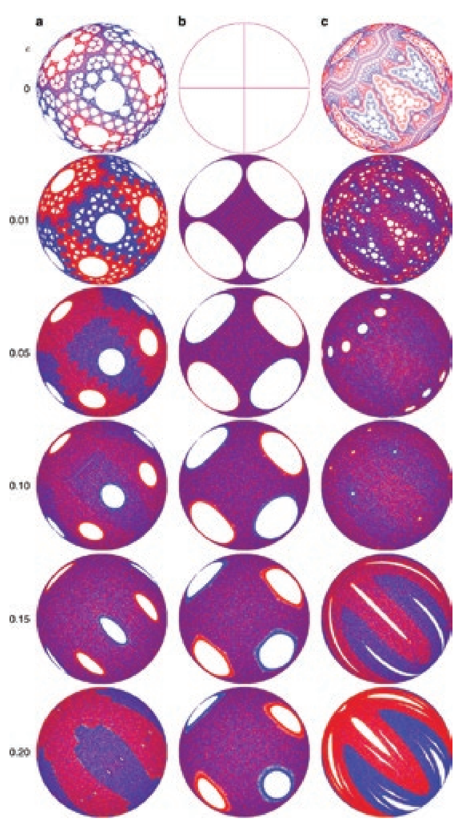
REGENERATIVE BANDAGE ACCELERATES HEALING IN DIABETIC WOUNDS

A simple scrape might not cause alarm for most people. For diabetic patients, an untreated scratch can turn into an open wound that could lead to a limb amputation or even death.

A Northwestern team led by Professor Guillermo Ameer has developed a new device, a regenerative bandage that quickly heals painful, hard-to-treat sores without using drugs. During tests, Northwestern's bandage healed diabetic wounds 33 percent faster than one of the most popular bandages currently on the market.

The secret behind Ameer's regenerative bandage is laminin, a protein found in most of the body's tissues, including the skin. Laminin sends signals to cells, encouraging them to differentiate, migrate, and adhere to one another. Ameer's team identified a segment of laminin—12 amino acids in length—called A5G81 that is critical for the wound-healing process.

Although Ameer's laboratory is specifically interested in diabetes applications, the bandage can be used to heal all types of open wounds. And because the bandage leverages the body's own healing power without drugs or biologics, it faces fewer regulatory hurdles. This means patients could see it on the market much sooner.



WHEN MIXING GRANULAR MATTER, ORDER AMONG DISORDER

Professors Julio M. Ottino, Paul Umbanhowar, and Richard Lueptow discovered that mixing yield-stress materials creates mixed and non-mixed regions, providing a fundamental beginning to understanding how to best design mixing protocols.

In question was how well granular material could be mixed in a basic system—a spherical tumbler. Would the material mix like a solid through a "cutting-and-shuffling" method similar to a deck of cards? Or, would it mix like a viscous liquid, such as honey, through a "stretching-and-folding" pattern?

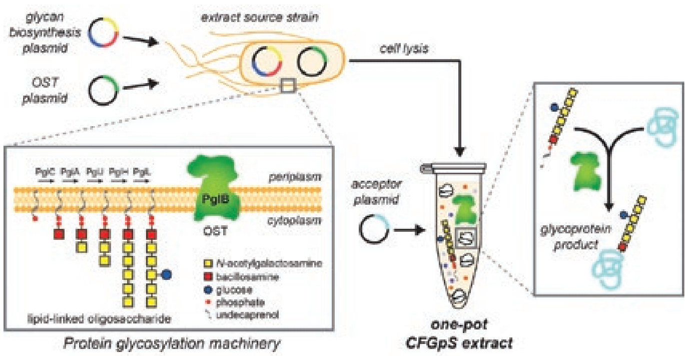
The researchers half-filled a spherical tumbler with two-millimeter-sized glass beads. When rotated, the top layer of beads flowed like a fluid to the bottom of the sphere, while other beads remained in place, even on various axes, like a solid. They found regions that mixed and regions that did not. This resulted from the interplay between the mixing methods, cutting-and-shuffling and stretching-and-folding.

60

Years since the formation of the materials science department

2,600

Versions of a protein studied by Danielle Tullman-Ercek to create a self-assembling virus shell that could be used in drug delivery



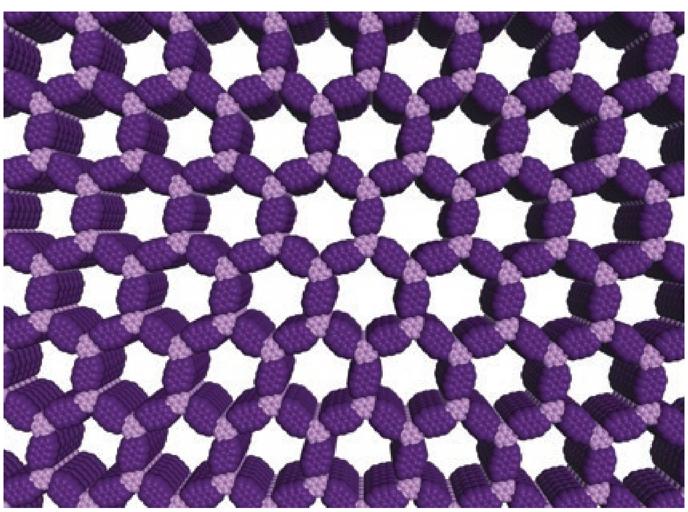
“This collaboration is the perfect combination of enabling technologies from our labs. That’s exciting.”

MICHAEL JEWETT PROFESSOR OF CHEMICAL AND BIOLOGICAL ENGINEERING

Bioengineers Create Pathway to Personalized Medicine

Engineering cellular biology—minus the actual cell—is a growing area of interest in synthetic biology. It’s known as cell-free protein synthesis, or CFPS, and has the potential to provide sustainable ways to make chemicals, medicines, and biomaterials. One challenge stands in the way: the ability to manufacture proteins with a carbohydrate attachment, known as glycosylated proteins.

Professor Michael Jewett and collaborators from Cornell University have developed a first-of-its-kind system that leverages recent advances in CFPS while adding the crucial glycosylation component in a simplified, “one-pot” reaction. In the future, their cell-free glycoprotein synthesis system could be freeze-dried and reactivated for point-of-use protein synthesis by simply adding water.



NORTHWESTERN RESEARCHERS ACHIEVE UNPRECEDENTED CONTROL OF POLYMER GRIDS

Synthetic polymers—nylon and polyester, Teflon and epoxy, to name just a few—are ubiquitous. All are made up of long, linear structures that can tangle. Chemists have dreamed of making polymers with two-dimensional, grid-like formations, but the first examples of such structures, called covalent organic frameworks, are known for poor quality. A Northwestern research team including Professor Nathan Gianneschi is the first to produce high-quality versions of these materials, demonstrate their superior properties, and control their growth.

The researchers developed a two-step growth process that produces organic polymers with crystalline, two-dimensional structures. The precision of these structures and the empty space their hexagonal pores provide will allow scientists to design new materials with desirable properties, with potential applications in water purification, electricity storage, body armor, and other tough composites.

10

Percentage of all human genes studied due to well-meaning policy interventions to promote research but result in additional work on the most established research topics, according to research by Luís Amaral's lab

70

Number of PhD students who attended first 2018–19 Whole-Brain Leadership for PhD Students Seminar Series lecture

DNA DRIVES DESIGN PRINCIPLES FOR LIGHTER, THINNER OPTICAL DISPLAYS

A team led by Northwestern Engineering’s Chad Mirkin and Weinberg College of Arts and Sciences’s George Schatz has developed a new set of design principles for making photonic crystals akin to those typically used in computer, television, and smartphone displays. By using synthetic DNA to assemble particles into crystalline lattices, the researchers have opened the door for making displays much lighter and thinner than the ones currently available.

Northwestern’s approach replaces the layered polymers found in a display’s back-reflector—a mirror-like device that directs the light emitted by the LCD to the viewer—with gold nanocrystals. By spacing the nanocrystals apart to leave air among them, the researchers created a lighter, more compact, precisely designed, and reconfigurable structure that is still highly reflective.

Image by Justin Muir

New Biotech Technique Accelerates Protein Therapy Research

Professors Milan Mrksich and Michael Jewett have developed a new biotech technique that promises to accelerate research into protein therapies. The new platform characterizes and optimizes sequences for making glycoproteins by combining mass spectrometry technology from Mrksich's lab with expertise in glycosylation and rapidly making proteins from Jewett's.

Glycosylation—the attachment of sugars to proteins—plays a critical role in how proteins form and work in cells, and in the study of disease and biotechnologies. The new technique promises to speed up the testing of compounds for potential new drugs. As recent as a few decades ago, drugs were based on natural products that were isolated and characterized from plants and other natural sources.

"We have radically accelerated the process. Where researchers today can evaluate a couple of hundred potential glycosylation tags in a given period, we've brought together two high-throughput technologies that allow us to evaluate several thousand in that same time frame."

MILAN MRKSICH HENRY WADE ROGERS PROFESSOR OF BIOMEDICAL ENGINEERING

DESIGN APPROACH DEVELOPED FOR IMPORTANT NEW CATALYSTS FOR ENERGY CONVERSION AND STORAGE

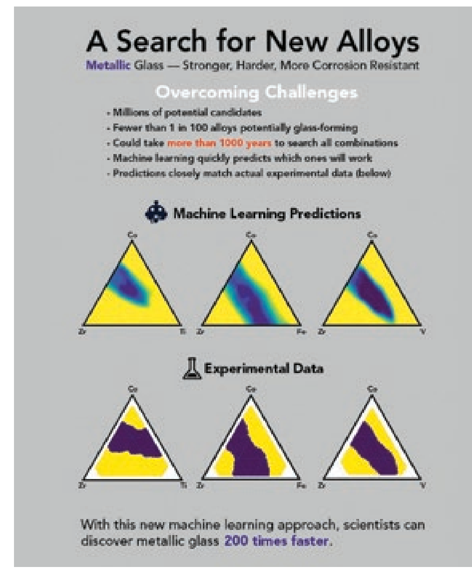
Professors Chad Mirkin and Christopher Wolverton have discovered a new approach for creating important new catalysts to aid in clean energy conversion and storage. The design method could also impact the discovery of new optical and data storage materials, catalysts that impact pharmaceutical synthesis, and catalysts that make the processing of petroleum products more efficient and much less costly.

88

Number of diverse coral species studied using data analysis by a team of undergraduate students as part of a crowdfunded study

2

Number of Emerging Frontiers in Research and Innovation grants received by Northwestern Engineering from the National Science Foundation for chromatin and epigenetic engineering research

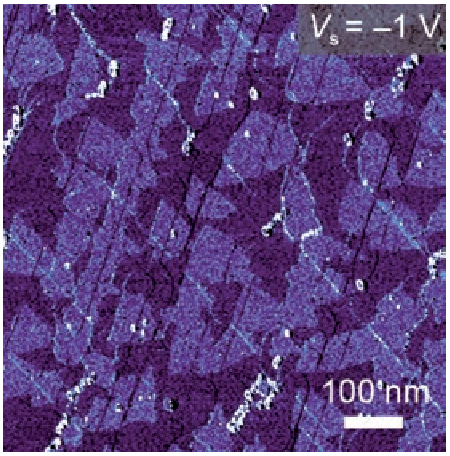


ARTIFICIAL INTELLIGENCE ACCELERATES DISCOVERY OF METALLIC GLASS

Scientists at Northwestern University, the US Department of Energy's SLAC National Accelerator Laboratory, and the National Institute of Standards and Technology have reported a shortcut for discovering metallic glass at a fraction of the previous time and cost.

The research group used a system at SLAC's Stanford Synchrotron Radiation Lightsource that combines machine learning with experiments that quickly make and screen hundreds of sample materials at a time. This helped researchers discover three blends of ingredients that form metallic glass at speeds 200 times faster than before.

The goal, says Professor Christopher Wolverton, who led the machine-learning work, is for scientists to be able to scan hundreds of sample materials, get almost immediate feedback from machine-learning models, and have more samples ready to test the next day.



IN BOROPHENE, BOUNDARIES ARE NO BARRIER

When researchers synthesize borophene, the two-dimensional form of boron, they often observe defects in the material. A team including Northwestern Engineering's Mark Hersam and colleagues from Rice University discovered that these defects surprisingly assemble into ordered structures that preserve the new material's unique electronic properties.

"Most theoretical predictions assume that borophene has a perfect crystalline structure," Hersam says. "But defects are inevitable in borophene, which is grown in the lab, so it's important to study these defects."

Since a team of scientists, including Hersam, first synthesized borophene in 2015, the new material has gained attention for its metallic behavior, optical transparency, and stretchable, flexible nature, ideal properties for wearable technologies and interactive displays.

2

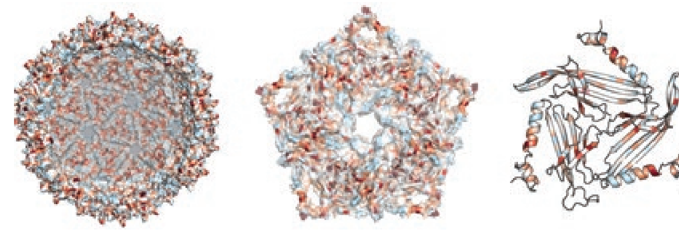
Number of Northwestern alumnae who topped the 2018 *Business Insider* list of the most powerful female engineers

80

Number of architects, civil and environmental engineers, and transportation experts who attended a workshop on resilient communities organized by Kimberly Gray

HEALTHY RED BLOOD CELLS FLOW IN AN ORDERED PATTERN UNLIKE THEIR DISEASED COUNTERPARTS

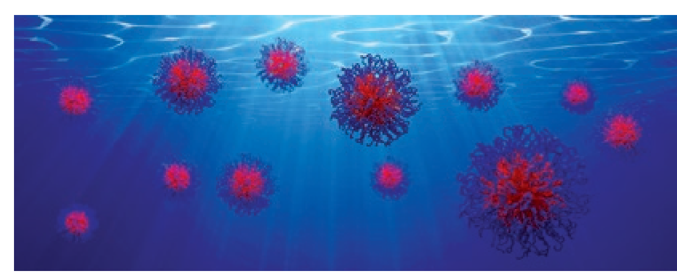
An interdisciplinary, international team of researchers including Northwestern Engineering's Petia Vlahovska discovered that healthy red blood cells assemble into a two-dimensional crystal pattern, whereas pathological red blood cells succumb to disorder. The findings ignite the possibility of a novel diagnostics tool to detect blood pathologies in diseases such as sickle cell anemia, a disorder the World Health Organization has long identified as a prominent global health issue.



New Methodology Helps Study of Promising Targeted Drug Delivery Scaffold

Professor Danielle Tullman-Ercek and researchers at the University of California, Berkeley, developed a new way to manipulate virus shells that self-assemble from proteins. Viruses have shells that can be used for good. Their stability holds potential for disease detection and vaccination applications and makes them suitable to protect useful cargo, such as medications, that can be delivered to specifically targeted cells.

Researchers examined which protein mutations broke the scaffold of a bacterial virus called the MS2 bacteriophage. To do that, the team developed a new technique called SyMAPS, which separated the mutated scaffold proteins that remained intact from those that broke apart during mutation.

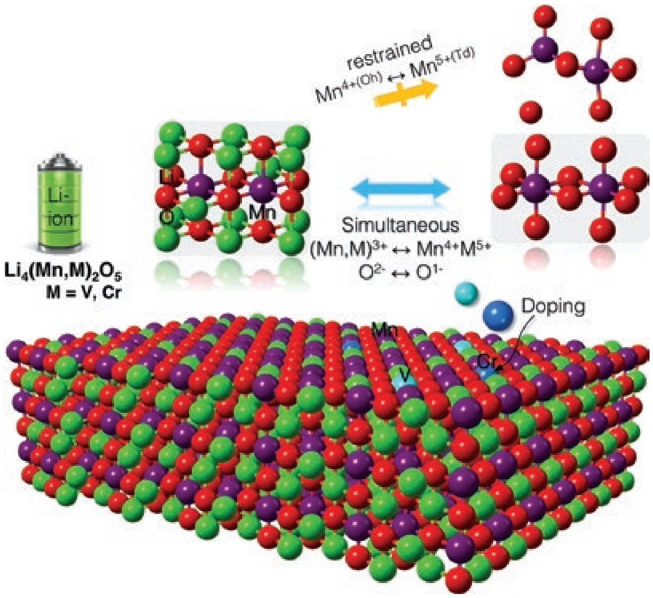


WATCHING NANOMATERIALS FORM IN 4D

Researchers from Northwestern and the University of Florida developed a new type of transmission electron microscope that takes dynamic, multi-frame videos of nanoparticles as they form. Knowing how these particles change in space and time could change how researchers design future paints, coatings, lubricants, and drug-delivery systems.

The team developed a robotic system that assembled the chemicals needed to make the particles. Then, using a microscope's electron beam, they triggered a reaction that caused micelles, a type of spherical nanomaterial, to begin to form. Although a camera system attached to the microscope did not capture the micelles' entire transformation, researchers could see part of it.

"I'm pleasantly surprised that we pulled this part off," Northwestern Engineering's Nathan Gianneschi says. "But optimizing the system so we can see the reaction's entire trajectory will keep us busy for the next few years."



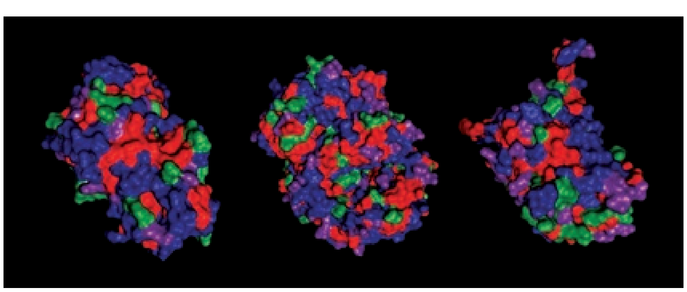
RESEARCHERS PREDICT MATERIALS TO STABILIZE RECORD-HIGH CAPACITY LITHIUM-ION BATTERY

A Northwestern research team has found ways to stabilize a new battery with a record-high charge capacity. Based on a lithium-manganese-oxide cathode, the breakthrough could enable smartphones and battery-powered automobiles to last more than twice as long between charges.

The team used high-throughput computations to find new ways to alloy the compound with other elements to enhance the battery's performance. "This battery electrode has realized one of the highest-ever reported capacities for all transition-metal-oxide-based electrodes. It's more than double the capacity of materials currently in your cell phone or laptop," Professor Christopher Wolverton says. "This sort of high capacity would represent a large advancement toward the goal of lithium-ion batteries for electric vehicles."

MAKING CARBON NANOTUBES AS USABLE AS COMMON PLASTICS

Using an inexpensive, simple solvent called cresol, Professor Jiaxing Huang has discovered a way to disperse carbon nanotubes at unprecedentedly high concentrations without the need for additives or harsh chemical reactions to modify the nanotubes. Huang also found that as the nanotubes' concentrations increase, the material transitions from a dilute dispersion to a thick paste, then a free-standing gel, and finally a kneadable dough that can be shaped and molded.



RESEARCHERS FIND WAY TO KEEP PROTEINS FUNCTIONING OUTSIDE THE CELL

Researchers from Northwestern and the University of California, Berkeley, have discovered a way to keep proteins active outside of a cell. The discovery could lead to new materials with functions now found only in living systems.

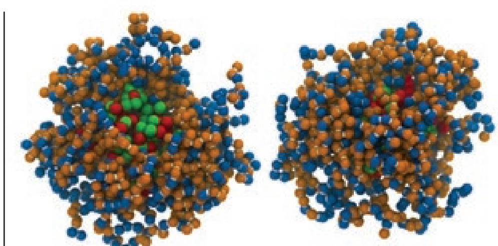
After UC Berkeley researchers created random heteropolymers (RHPs) to mimic a natural protein, Northwestern Engineering's Monica Olvera de la Cruz ran molecular simulations to show that RHPs would interact favorably with protein surfaces, wrap around protein surfaces in organic solvents, and adhere weakly in water, leading to correct protein folding and stability in a non-native environment.

8

Years spent developing electronic materials, device designs, and manufacturing techniques for biodegradable devices by John Rogers and his lab

21

Number of students in the inaugural Robot Design Studio, a two-quarter multidisciplinary course that tasked student teams to design and build sophisticated robotic devices



RESEARCHERS FIND ENZYMES NATURALLY SELECT THEIR OWN POLYMER SEQUENCES

As free-flowing enzymes travel amid a sea of polymers, Northwestern Engineering researchers have found those enzymes prefer to join certain polymer sequences over others, a discovery that could lead to a diverse array of applications ranging from nuclear waste processing to drug delivery.

Performing computer simulations at Quest, Northwestern's high-powered computational facility, researchers examined the key factors that determined the coverage of the random copolymers with different types of enzymes in different solvents.

"From all these batches of randomness, we discovered each particular enzyme selects a sequence it likes best," says Professor Monica Olvera de la Cruz, who led the study. "That's important because it sheds light on how we might design the composition of a batch of polymers so they will disperse enzymes actively in non-biological environments."

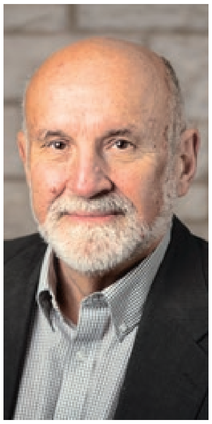

Julio M. Ottino

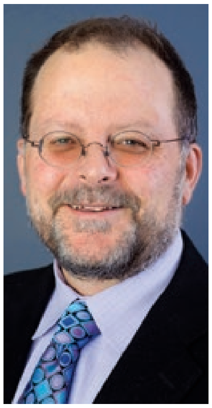

Wendy Murray


Yonggang Huang


Linda Broadbelt


Michael Jewett


Kornel Ehmann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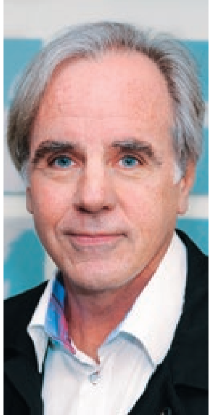
Jonathan Rivnay


Isaac Daniel


Robert Murphy


Zdeněk P. Bažant


Tobin Marks

Faculty Awards

Julio M. Ottino Presented with AIChE's Founders Award The annual award from the American Institute of Chemical Engineers recognizes one individual for their impact in the chemical engineering field and whose achievements have advanced the profession.

Linda Broadbelt Receives AIChE's R.H. Wilhelm Award The award recognizes her contributions to the field of chemical reaction engineering.

Three Named AIMBE Fellows Patrick Kiser, Robert Murphy, and Wendy Murray were elected to the American Institute for Medical and Biological Engineering's College of Fellows, recognizing their contributions advancing the fields of medical and biological engineering through research, practice, or education.

Michael Jewett Receives Young Investigator Award *Biochemical Engineering Journal*'s Young Investigator Award honors Jewett for outstanding excellence in research and practice in the field of biochemical engineering.

Jonathan Rivnay Recognized with NSF CAREER Award The National Science Foundation award honors young faculty members who exemplify the role of teacher-scholar through outstanding research, excellent education, and the integration of education and research.

Zdeněk P. Bažant Honored with ASCE's Alfred M. Freudenthal Medal The award from the American Society of Civil Engineers is generally considered the highest recognition for contributions to structural safety and probabilistic mechanics.

Yonggang Huang Awarded Zdeněk P. Bažant Medal for Failure and Damage Prevention The medal from the American Society of Civil Engineers recognizes an individual whose career demonstrates significant contributions to the engineering science of failure and damage prevention.

Kornel Ehmann Receives Two Awards for Manufacturing Work Ehmann received the 2018 Hideo Hanafusa Outstanding Investigator Award, recognition of his contributions to the field of flexible automation. He also received the SME Education Award, which honors the educator most respected for the development of manufacturing-related curricula, fostering sound training methods, or inspiring students to enter the profession of manufacturing.

Isaac Daniel Elected to the Academy of Athens The Academy of Athens is Greece's oldest research institution, and membership is considered the most prestigious academic recognition in the country.

Tobin Marks Elected to the Italian National Academy of Sciences Founded in 1603, the Academy's illustrious members include Galileo Galilei, Louis Pasteur, and Albert Einstein. Marks also received the Harvey Prize from Technion - Israel Institute of Technology, recognizing breakthroughs in science and technology.

WHERE MATH AND BIOLOGY MEET

At the new Center for Quantitative Biology, Northwestern Engineering mathematical scientists work alongside developmental biologists to study the “rules of life.”

On an August morning in a Northwestern developmental biology lab, a team of researchers casts its collective eyes on thousands of roundworms culled from sites around the globe.

Using robotics to scan hundreds of roundworms each second, the lab members gather a range of measurements on the nematodes' growth—or, as Erik Andersen, an assistant professor of molecular biosciences in the Weinberg College of Arts and Sciences, succinctly puts it, "Getting a bunch of numbers about a bunch of worms."

It's important work. Studying these simple creatures can help unlock some of nature's most profound mysteries ranging from how metabolism sets development to how genetic changes spawn distinct differences. As such studies in life sciences become more reliant on data, biologists need mathematical models of these complex systems, expertise that mathematical scientists from Northwestern Engineering bring to a new partnership with University biologists to take research to higher levels.

"Mathematicians can put things into a model and then test that model quickly under different conditions," says William Kath, professor of engineering sciences and applied mathematics. "This can lead to more informed and calculated experiments and tilt the balance in favor of understanding things better and faster."

The commingling of developmental biology and mathematics—the aptly titled field of quantitative biology—is becoming increasingly commonplace. As developmental biologists, a group long reliant on qualitative descriptions, embrace more quantitative experiments, mathematicians have emerged as valuable allies helping to make sense of the numbers and reveal novel phenomena.

NORTHWESTERN LEADS THE WAY

In May, the University received a $10 million grant from the National Science Foundation (NSF) and the Simons Foundation to establish the NSF-Simons Center for Quantitative Biology (CQuB). The new center focuses on research in this burgeoning interdisciplinary field that marries mathematical models and quantitative analysis with molecular, cellular, and organismal biology to deepen understanding of the "rules of life."

Along with Kath, McCormick faculty involved in CQuB's research include Madhav Mani, assistant professor of engineering sciences and applied mathematics; Luís Amaral, professor of chemical and biological engineering; and Neda Bagheri, assistant professor of chemical and biological engineering, among others.

"With neither mathematics nor biology going away anytime soon, this new center is a way for us to collaborate better, generate critical mass, and drive discovery," says Kath, who is charged to lead CQuB alongside Richard Carthew, the Owen L. Coon Professor of Molecular Biosciences at Weinberg.

Using cutting-edge technologies, such as artificial intelligence, genomics, and microscopy, alongside hypothesis-driven mathematical modeling and data-driven analysis, the CQuB is addressing complex, fundamental questions about life and nature. The implications for science and medicine are significant.

While developmental biologists run the experiments and supply the data, McCormick scholars leverage statistical, computational, and big data techniques to guide experimentation and detect how genetic codes generate complex life. For instance, Niall Mangan, assistant professor of engineering sciences and applied mathematics, takes Andersen's numbers and builds mathematical models detailing the worms' developmental rates.

"The mathematical and computational scholars bring expertise, knowledge, and ideas to a previously qualitative discipline and push it into something it couldn't otherwise be," Andersen says.

NEXT UP, FROGS AND FLIES

Madhav Mani, meanwhile, specializes in developing quantitative image-analysis tools and mathematical models to guide new measurements and synthesize live imaging data. "Recent advances in live fluorescent imaging provide us with a dynamic and spatially resolved view of organismal development," Mani says. "But what's needed now are new mathematical tools and models that can help usher in an even deeper physical understanding of development."

Currently, Mani, who has long worked with experimental labs studying the dynamics of organismal development, has two in-process projects at CQuB: one with Carthew to understand fly development, and another with Carole LaBonne, chair and professor of molecular biosciences at Weinberg, to investigate frog development. "The upside of learning fly and frog development is the potential to reveal general principles," Mani says.

"Of course there is the potential of generality through evolutionary conservation, but there can also be generality at the level of emergent physical principles," Mani adds. "This is what drives me and focuses my work."

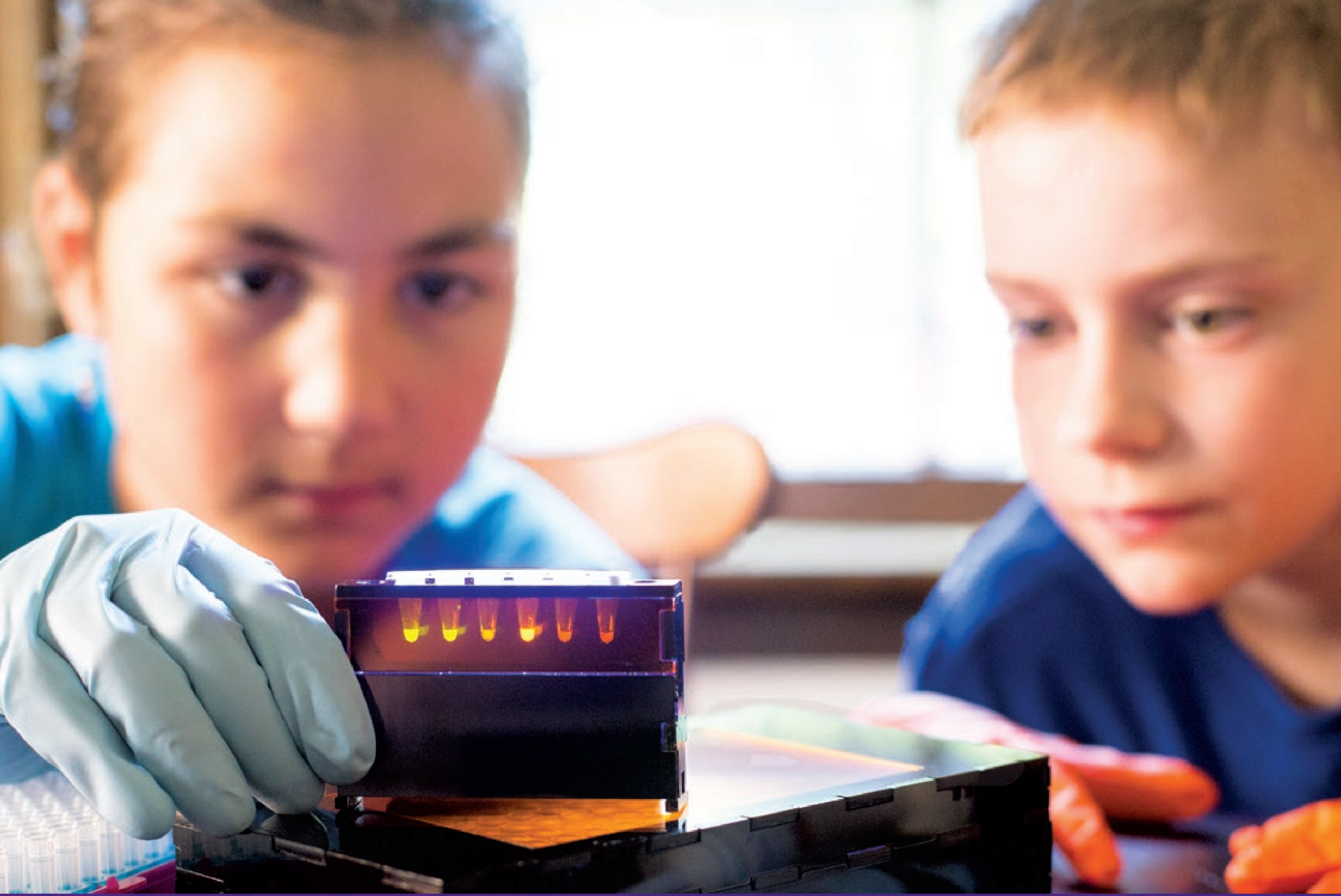
Also, the Center is awarding funding to two "high-risk, high-reward research" projects each year—10 over the grant's five-year run. "Think of this as early seed funding for a startup," Mani says. "These awards will help get daring ideas off the ground so researchers can gather the preliminary data they need to pursue later funding from the likes of NSF and the National Institutes of Health."

BEYOND THE RESEARCH

The Center offers an assortment of undergraduate, graduate, and postdoctoral programming designed to foster collaborations and deepen interest in quantitative biology. In addition, the Visiting Scholars Program offers researchers a six-month stay at Northwestern, while an annual conference on quantitative approaches in biology looks to stimulate the cross-fertilization of ideas through presentations, roundtable discussions, and a seminar on collaboration in team science.

The creation of the Center is "a watershed moment," Mani says. "The best science sits at the interface of what you want to do and what you can do. This funding gives us the confidence and time to pursue thoughtful research and to demonstrate what can be done."

DANIEL P. SMITH



SYNTHETIC BIOLOGY BASICS, BIT BY BIT

New educational kits, BioBits, aim to inspire the next generation of synthetic biology researchers.

For teachers like Tom Martinez, the standard biology curriculum can feel a bit stale—teaching the same old units, recounting facts that have been passed down for decades. Yet science teachers often find incorporating cutting-edge concepts into their curriculum difficult because they feel isolated from the latest research.

"As a teacher, you're not part of what's going on in the real world of science," says Martinez, who teaches AP biology and biotechnology at Glenbard East High School in Lombard, Illinois. "You can get stuck in your same patterns. Teachers are a tough crowd. We like what we like, and change needs to be easy and convenient. You need to get some bang for your buck."

Martinez and his like-minded peers are exactly the crowd Michael Jewett and his graduate student Jessica Stark had in mind when they and their collaborators developed BioBits, new educational biology kits that teach the basics of synthetic biology through simple, hands-on experiments.

Even better, the kits provide a cheap and easy way to show how basic biological reactions work by engaging students' sight, smell, and touch. For example, BioBits can easily produce fluorescent reactions that dazzle the eye or olfactory reactions that create a banana smell without the technical machinery usually required to achieve such effects.

"As scientists and engineers, we all had that one teacher in high school who got us excited about science," says Jewett, Northwestern Engineering professor of chemical and biological engineering. "We had hands-on experiential, visual experiences that made us think, 'I need to learn more about that.' My students and I are dedicated to finding ways to inspire others to get excited about science in that same way."

TRANSLATING THE LAB TO THE CLASSROOM

The idea for the kits came together from several avenues. Jewett's lab has been developing cell-free translational systems that take the cells' inner systems involved in protein synthesis and metabolism and repurpose them for applications in medicine and energy. The process essentially uses the machinery inside the cell without having to fight the cell's natural evolutionary objective.

Research like this and other studies being conducted in Northwestern's Center for Synthetic Biology, where Jewett serves as co-director, has the potential to create new targeted therapeutics and sustainable chemicals and next-generation materials. But conducting synthetic biology experiments typically requires expensive incubators, freezers, and specialized tools like spectrometers, which makes such experimentation infeasible in a high school classroom.

Stark saw this disconnect first hand. For years she helped with the Jewett lab's annual National Science Foundation-sponsored Research Experience for Teachers, which brings Chicagoland middle and high school science teachers to the Evanston campus each summer to learn about the latest research in the field.

"While the teachers really enjoyed the experience in our lab, they said it wasn't translating well into the classroom, where they didn't have the same access to experimental resources that we do at a university," she says. "I made it my goal to develop a hands-on experience that could be run by anyone, anywhere."

CREATING A KIT FOR LESS THAN $100

Meanwhile, at the Massachusetts Institute of Technology, James Collins's lab had been taking those cell-free systems and freeze-drying them for use in molecular diagnostics. That process makes the system stable, eliminating the need for freezers.

Seizing an opportunity for collaboration, Jewett connected with Collins, the Termeer Professor of Medical Engineering and Science and member of the core faculty at Harvard University's Wyss Institute; the two combined their technology and developed freeze-dried cell-free pellets for educational kits. As a result, to initiate a basic reaction of biology—the transcription of DNA into RNA, and then the translation of that RNA into a protein—a high school student would just need to add DNA and water and let the mixture incubate.

Together, the professors and graduate students at both schools asked themselves two questions: "Can we take this technique and create educational kits to teach students the basics of synthetic biology?" And, "Can we make it available for less than $100, a price point affordable for school systems?"

The answer was "yes," and the result was BioBits Bright, a kit that contains six different freeze-dried templates. When students add water to create the reactions and let the reactions incubate, they come back to find that each template fluoresces a different color.

"When we tested it with students, they just had so much fun seeing that visual output," Stark says. "You get this glowing result that both validates you did everything right and makes abstract biology concepts more concrete."

Photographs by Megan Beltran

High school students watch Northwestern Engineering's Jessica Stark (center) and Michael Jewett demonstrate BioBits.

The team then expanded on the idea to create BioBits Explorer, which includes experiments to engage other senses. One experiment creates a compound that smells like bananas; another creates a hydrogel that students can touch and squish. "With these kits, students can carry out, in a day, the most core process of living systems," says Jewett, Charles Deering McCormick Professor of Teaching Excellence.

"IT KIND OF BLOWS THEM AWAY."

Stark worked with the Office of Community Education Partnerships at Northwestern to test the kits with local students and teachers and worked with teachers to develop a supporting curriculum. "Teachers helped us understand what would be feasible in the classroom," Stark says. "We wondered if it was even going to work in their hands. It was really nice to see the teachers and students get the intended result the very first time."

Martinez, a former Research Experience for Teachers participant, was an early tester of the kits. Right away, he saw them as a "fresh and new and interesting" element he could fit within his genetics curriculum.

"It's a really nice melding of classroom experience with bench experience," he says. "It's going to make molecular engineering more accessible and easier for students and teachers to do."

Martinez even tested the kits with students in an after-school club. He says they loved it.

"When you're 16 or 18 years old, you have no idea about any of this stuff," he explains. "When they first see it, it kind of blows them away because it's so foreign. It allows them to be creative with the genetic constructs they want to see. We spend all our time deconstructing living things to see how they work, and until now, we didn't spend any time trying to influence a cell to do what we want it to do."

INSPIRING THE NEXT GENERATION OF SYNTHETIC BIOLOGISTS

The team published their work in August 2018. Since then, they have had more than 140 requests for kits. Right now, Stark serves as the sole manufacturer, creating and providing kits as she can. The team is working with Collins's graduate student Ally Huang and Wyss Technology Development Fellow Peter Nguyen to find a partner to distribute the kits. The goal is to create a nonprofit to scale up manufacturing and distribution.

The team is also developing more activities with the kits and envisions creating a one-stop database of open-source curricula, worksheets, and ideas for new experiments. The hope for both Stark and Jewett is that the kits will ultimately inspire high school students to pursue STEM careers.

"Over the next 50 to 100 years, the ability to engineer biological systems and program the living world will become much more commonplace," Jewett says. "To me, that's one of the reasons these kits are so important. We need to inspire a generation of biological engineers who can meet that need."

EMILY AYSHFORD

CENTER FOR SYNTHETIC BIOLOGY BUILDS ON SUCCESS

The creation of BioBits was just one achievement in a successful year for the Center for Synthetic Biology, which has experienced national recognition through high-profile awards and outreach programs, growth among new members and collaborators, and unprecedented success in garnering funding for next-generation research in building biological systems.

Among some of the achievements:

FUNDING

Faculty members within the Center have received millions of dollars in grant funding this year.

Josh Leonard and **Neda Bagheri** received the first-ever research project grant (R01) dedicated to synthetic biology from the National Institutes of Health (NIH).

Milan Mrksich and **Michael Jewett** received a $6.25 million Multidisciplinary University Research Initiative grant from the US Department of Defense to develop chemical methods for controlling the conformations and functions of proteins.

Danielle Tullman-Ercek, **Michael Jewett**, and **Keith Tyo** received a combined $15 million in funding to develop new technologies to engineer microorganisms to produce sustainable chemicals.

AWARDS

Michael Jewett received the 2018 Young Investigator Award from the [illegible].

Josh Leonard received a 2018 Charles Deering McCormick Professor of Teaching Excellence award. **Michael Jewett** received the award in 2017.

NEW MEMBERS

The Center added two new members:

Arthur Prindle, assistant professor of biochemistry and molecular genetics in the Feinberg School of Medicine, joined from a postdoctoral fellowship at University of California, San Diego, and is the first Center faculty member to be based in Feinberg. His research looks to understand how molecular and cellular interactions give rise to collective behaviors in microbial communities and to use that understanding to develop new synthetic biology approaches through microbiome engineering.

Neha Kamat, assistant professor of biomedical engineering, joined Northwestern from Harvard University, where she served as a NASA Postdoctoral Fellow. She integrates materials science and synthetic biology to design artificial cells to understand and recreate targeted cellular behaviors. These systems have potential to be used as targeted drug delivery and novel sensor systems, and as an approach to studying fundamental signaling processes within cells and systems of cells.

RESEARCH

Milan Mrksich and **Michael Jewett** developed new platforms for characterizing and optimizing sequences for making glycoproteins using cell-free protein synthesis and mass spectrometry. Their work was published in *Nature Communications* and *Nature Chemical Biology*.

Neda Bagheri designed a new machine-learning algorithm that can help connect the dots among the genes' interactions inside cellular networks. Called Sliding Window Inference for Network Generation, or SWING, the algorithm uses time-series data to reveal the underlying structure of cellular networks. The work was published in the *Proceedings of the National Academy of Sciences*.

Julius Lucks developed a powerful and versatile tool that achieves gene activation thousands of times better than nature. Lucks created the switch by molecularly programming an RNA molecule called Small Transcription Activating RNA, or STAR, that his group had previously discovered. He then used an algorithm to optimize STAR for specific applications. His NIH-funded work was published in [illegible].

Danielle Tullman-Ercek developed a new way to manipulate a virus shell that self-assembles from proteins and holds promise as a carrier for disease detection, drug delivery, and vaccinations. She and her collaborators developed a new technique that separated out mutated scaffold proteins that remained intact from those that broke apart during mutation to understand how repurposed virus proteins could be used in medicine. The study appeared in *Nature Communications*.

OUTREACH

Joshua Leonard recently presented a TEDx talk on synthetic biology at the American School Foundation of Monterrey, Mexico, to inspire high school students to pursue STEM careers.

Danielle Tullman-Ercek and **Michael Jewett** led a new 10-week Research Experience for Undergraduates program, which brought in eight students from around the country this past summer to conduct research in synthetic biology laboratories.

A WORLD WITHOUT

HOW INSECURE IS THE WORLD'S WATER SUPPLY? FACULTY IN THE CENTER FOR WATER RESEARCH WANT TO KNOW.

Northwestern Engineering PhD students Liliana M. Hernandez Gonzalez (left) and Vivien Rivera (right) check a water level sensor at the Gensburg-Markham Prairie, Markham, Illinois.

WATER

Cape Town made headlines earlier this year when it became the first major city to announce a specific end to its available water supply—a so-called "day zero." On that day, city officials said, water would be cut off for the majority of the 4 million residents in the region.

Though policies that were sprung into action delayed that day until at least 2019, water crises like this have become the new norm: droughts in California and Australia, flooding from storms like Hurricane Florence and Superstorm Sandy, and contaminated water in cities like Flint, Michigan.

As severe crises make the headlines, cities around the world are dealing with the new reality of water insecurity. Centuries-old infrastructure, combined with climate change and population growth in drier areas, has led to increased risk of large-scale water disruptions.

"Every event has been a wake-up call for everyone in that region," says Aaron Packman, Northwestern Engineering professor of civil and environmental engineering. "But these events are predictable. We know that they are happening, and that they are increasingly likely to happen. Is there a way to make investments in water security without every major city having to have its own disaster?"

As director of the Center for Water Research, Packman and his colleagues, along with collaborators around the world, are conducting research to understand the breadth of the problem and using that data to inform the design of next-generation, resilient systems.

Packman is eager to sound the alarm—and to provide tangible solutions. As an environmental engineer with a background in mechanical engineering and extensive post-graduate coursework in microbiology, he takes a multiscale approach to the problem. His own research ranges from understanding the physics of how particles like sand and rock flow in rivers, which has implications for land stability near rivers and deltas, to understanding how biofilms grow in natural and man-made systems, which can help researchers better understand how waterborne diseases are transmitted.

GLOBAL PARTNERS, LOCAL SOLUTIONS

One institution cannot tackle issues like these alone. That's why the Center for Water Research has developed partnerships with institutions around the world in countries like Taiwan, Colombia, and England and with global organizations like The Nature Conservancy and the World Wildlife Fund.

Photograph by Alex Garcia

"IF WE DO NOT DO THIS, WE WILL SEE A MAJOR CITY RUN OUT OF WATER IN THE NEXT 10 YEARS."

AARON PACKMAN
PROFESSOR OF CIVIL AND ENVIRONMENTAL ENGINEERING

Several substantial partnerships are centered in Israel. Because of its dry climate, Israel made early investments in water resource development and technologies for water reuse and desalination. The Center has partnerships with Tel Aviv University and Ben-Gurion University, which have led to student and faculty exchanges as well as joint research projects.

"We can cross-supply information," Packman says. "We can help them solve water problems in Israel, and they can help us solve practical problems in Chicago."

UNDERSTANDING URBAN WATER DYNAMICS

For the past several years, Packman has also been working with collaborators across Chicago to understand stormwater dynamics within the region. The city provides an interesting test case: Chicago's water infrastructure was designed 150 years ago for a much smaller population and for weather events that were the norm then. Though it has a large freshwater supply from the Great Lakes, Chicago is now dealing with changing weather patterns that have given it another chronic problem: too much water in the wrong places, like basements and streets.

For Chicago and a number of other places, the prospects are high for a substantial increase in flooding that will overwhelm the infrastructure that was designed for historical weather conditions, Packman says.

Understanding water dynamics within a city is more challenging than it seems. Because placing sensors in deep underground pipes is difficult, no one knows, for example, how water is distributed beneath the surface when it rains, or how much drinking water is lost from leaky pipes. The American Society of Civil Engineers estimates that aging pipes lose 14 to 18 percent of treated water, which amounts to nearly 6 billion gallons a year.

"It's really rare, especially for a big city like Chicago, to go in and replace all the water infrastructure," Packman says. "It's hard to access and expensive to work on. You have to do a retrofit, which makes it even more difficult. Nobody has been able to start from scratch."

TURNING TO NATURE FOR DESIGN

Researchers do know that one way to reduce flooding within cities is with green spaces like parks and nature preserves, which can act as natural sponges in periods of heavy rainfall. So for the past four years, Packman and his colleagues have placed sensors in Indian Boundary Prairies, a nature preserve in Markham, Illinois, to determine how this natural green space affects water dynamics after rainstorms. Sensors measure soil moisture and rain and water levels.

"We want to know what happens when it rains. Where does it go? How much goes into the ground? Where is it stored? How long does it take to come out? What conditions cause flooding?" he says.

Collaborating on this project is Argonne National Laboratory and the University of Chicago's Array of Things, which uses the networked sensors to collect real-time data on Chicago's environment, infrastructure, and activity. Packman and collaborators have expanded their sensor network to sites like the Chicago Botanic Garden and Tuley Park in the city's Chatham neighborhood, which often experiences seasonal flooding.

The goal is to work with current partners, including The Nature Conservancy and the Metropolitan Water Reclamation District of Greater Chicago, to develop tools for analyzing and modeling water storage to understand the relationship between the city's surfaces—homes, parks, yards—and the sewer system below to prevent future flooding.

The team hopes to collaborate with those involved in green infrastructure projects to design new guidelines and predict performance for green spaces. "The strategies we're developing here could help solve problems around the world," Packman says.

WATER SCARCITY AT HOME

For Northwestern anthropologists like Sera Young, it is important to couple data on the physical environment with those from the human experience. She and her team study how flooding and other problems with water are understood, and how lack of access to the right amounts of water for health, hygiene, and economic productivity impacts human lives.

Water insecurity—through both scarcity and flooding—is an especially important issue for low- and middle-income countries. Around the world, an estimated 663 million people lack access to safe drinking water, and more than 4 billion people experience severe water scarcity for at least one month a year. While statistics like these capture how much water is available, Young realized there was no systematic way to measure water insecurity at the household level.

"We know how to measure food insecurity," says Young, an assistant professor of anthropology in Northwestern's Weinberg College of Arts and Sciences and faculty member within the Center for Water Research. "If we could measure water insecurity in the same way, it could help inform policies, evaluate how well programs are working, and identify vulnerable populations."

In addition to her work with Packman in Chicago, for the past three years, Young has been leading dozens of colleagues working at 28 sites in 23 countries to develop a cross-culturally valid scale that can measure household-level water insecurity. After interviewing community members and testing questions related to water quality, accessibility, and stability, the group has identified the best survey questions to help them measure perceived water security. The next step is incorporating those questions into large-scale surveys. Then, they can analyze the data to understand how water insecurity affects issues such as child growth, stress and anxiety, economic productivity, and agriculture.

"I want to be able to quantify the impact that the wrong quantity or quality of water has on the world's most vulnerable people," Young says. "I think the data from research of this scale will indicate just how far-reaching water insecurity problems have become. Water is used for so much, but it's not like oil, which can be replaced with other sources of energy. There's no replacement for water."

Young is also working with her husband, Julius Lucks, associate professor of chemical and biological engineering, to use his RNA-based technology to develop a simple, inexpensive test that could determine water quality in Chicago or the low-income countries in which Young most often works. Tests for current contaminants, like E. coli, are expensive, and getting results can take more than 24 hours. "I want it to be as easy and as clear as a pregnancy test," she says.

PREVENTING A MAJOR CITY FROM RUNNING DRY

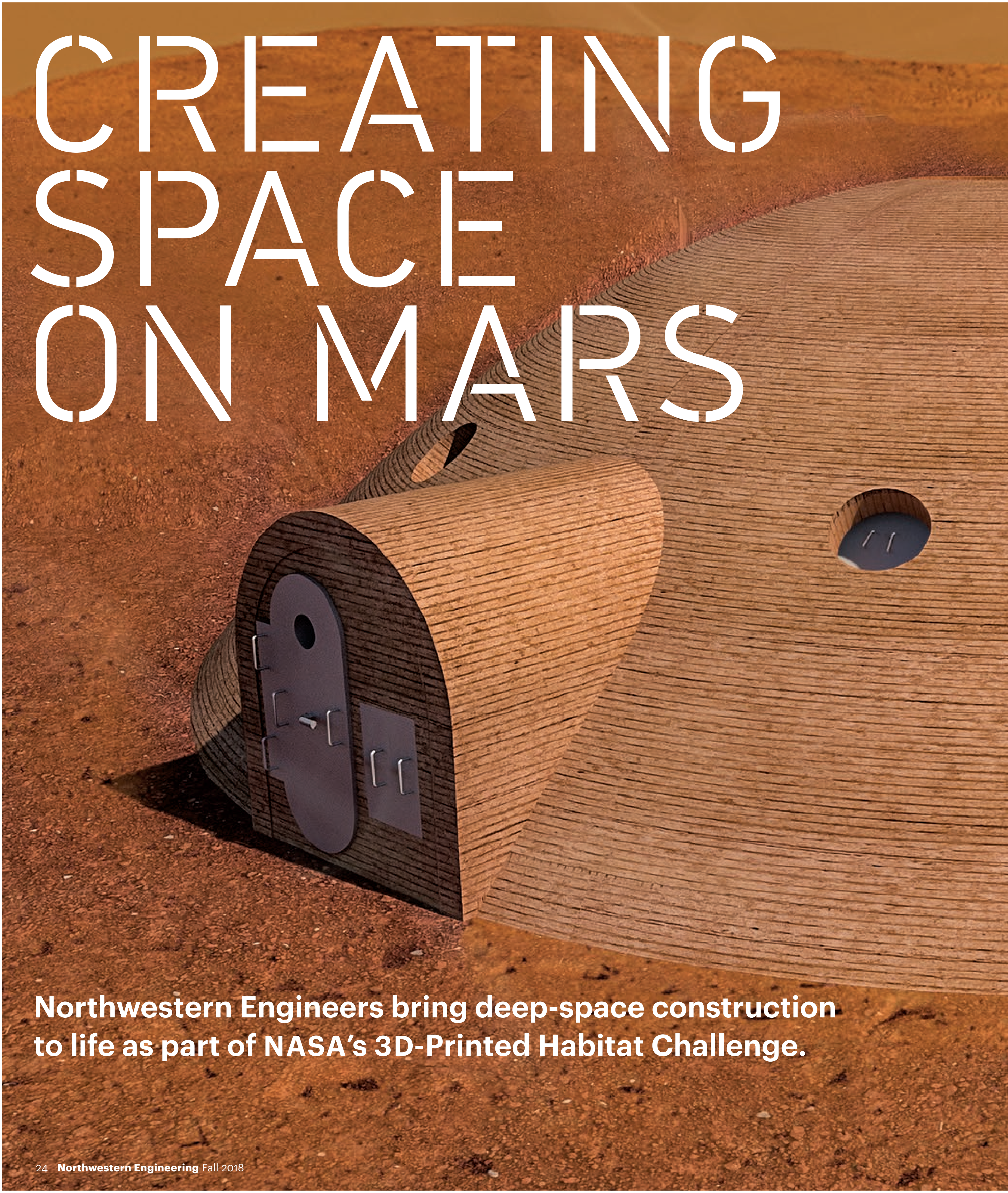
Young, Packman, and their collaborators recently received funding to develop a framework for assessing and predicting extreme weather impacts in cities. That framework would then be used to develop maps and green infrastructure strategies to reduce vulnerability to extreme weather.

Achieving water security will require both social and technical advances, Packman says. First, cities and regions must recognize that water supplies are vulnerable, and that water systems need to be designed to be resilient to accommodate shifting weather patterns.

Second, cities should incorporate nature-based solutions, like green spaces, and should consider placing modular, smaller water treatment sites at the point of use instead of funneling everything through one centralized plant. That way, water could be treated for its specific need—drinking, agriculture, industry—much more efficiently.

"If we don't do this, we'll see a major city run out of water in the next 10 years," he says. "It could be Cape Town, it could be Phoenix. It's not as far away as people think."

EMILY AYSHFORD



CREATING SPACE ON MARS

Northwestern Engineers bring deep-space construction to life as part of NASA's 3D-Printed Habitat Challenge.

The first humans to visit Mars are likely alive today, and NASA is planning to send one or more of them to the planet by 2040.

While exciting, the plan faces enormous logistical challenges. NASA scientists know that travel between Earth and the Red Planet takes nearly 10 months, and that room on board any spacecraft will be at a premium. What's not known, however, is how the need for basic necessities will be met: What materials are available to create homes and other structures? What tools could be used? How will man-made structures weather the Martian climate?

Though Mars is the planet most similar to Earth, crafting Martian living will require creative and efficient solutions. NASA put out a call for help, inviting thought leaders in industry and academia to the 3D-Printed Habitat Challenge to develop insights and create new technologies to manufacture a home on Mars using materials native to the planet. An interdisciplinary team led by Northwestern Engineers has answered with an award-winning design created with "Marscrete."

top to bottom
LAB, KITCHEN, CENTRAL SPACE

> "Our design initially started with one main entrance, but after we were given requirements from NASA to include a rover hatch, we decided to make the whole habitat symmetrical."
>
> **MATTHEW TROEMNER** PhD student

RESEARCH MOVES FROM EARTH TO MARS

In 2014, just about the time NASA launched its challenge, Gianluca Cusatis, Northwestern Engineering associate professor of civil and environmental engineering, was exploring the potential of 3D printing—also known as additive manufacturing—for housing applications here on Earth.

He focused on construction, an industry that has battled stagnant productivity gains for two decades. While 3D-printing technology dates back to the 1980s, its use in construction was limited to creating small mechanical objects. Cusatis points out, however, "You don't build small objects in civil engineering.

"We spent time learning what people were doing in the field of large-scale 3D printing," he adds, having led Northwestern's first workshop on the potential of large-scale 3D printing in 2017. The event brought together designers, architects, and engineers to explore how to print large structures—such as barracks in war zones or temporary housing in disaster areas—quickly and inexpensively with stronger, more durable, and more environmentally friendly materials.

While testing these practical solutions for Earth-bound buildings in difficult places, the team learned of a chance to apply their research to a much more challenging location—Mars. "While we were exploring these opportunities, we learned of the NASA challenge, and thought it was a chance to build enthusiasm for large-scale 3D-printing research on campus," Cusatis says.

Cusatis turned to Matthew Troemner, an incoming PhD student in his Quasi-Brittle Materials Research Group, to lead the project, and the buzz began. Troemner connected with peers who were studying civil engineering and mechanical engineering and were eager to assist. After realizing the need to broaden its expertise, the team spread the word throughout the University, expanding its ranks to more than two dozen students and faculty with backgrounds in materials science, chemical engineering, journalism, earth and planetary sciences, and political science to work on the NASA challenge.

"You don't often see such enthusiasm for civil engineering. We've always lived in houses and driven over bridges," Cusatis says. "We don't view civil engineering innovation as disruptive as cell phone technology. But this project got everyone excited."

"MARTIAN 3DESIGN" TAKES SHAPE

The Northwestern team entered the 3D-Printed Habitat Challenge in January 2018 during the On-Site Habitat Competition, which tasked participants to create virtual renderings of a 1,000-square-foot house that could be built on Mars with a 3D printer and equipped to house four astronauts for up to one year.

Called Martian 3Design, the team's habitat combines sound structural engineering principles, building techniques that leverage Martian materials, and an intuitive floor plan that maximizes private and common spaces and resource efficiency. Features of the team's design include:

A 3D-printable inner spherical shell and outer parabolic dome that protect the house against the harsh Martian climate

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An interior layout that separates wet rooms (lab, kitchen, bathroom) from dry rooms (bedrooms, workstations) to limit the resources needed for construction

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Two hatch openings, located directly across from each other, which allow habitat units to easily connect to each other and foster community

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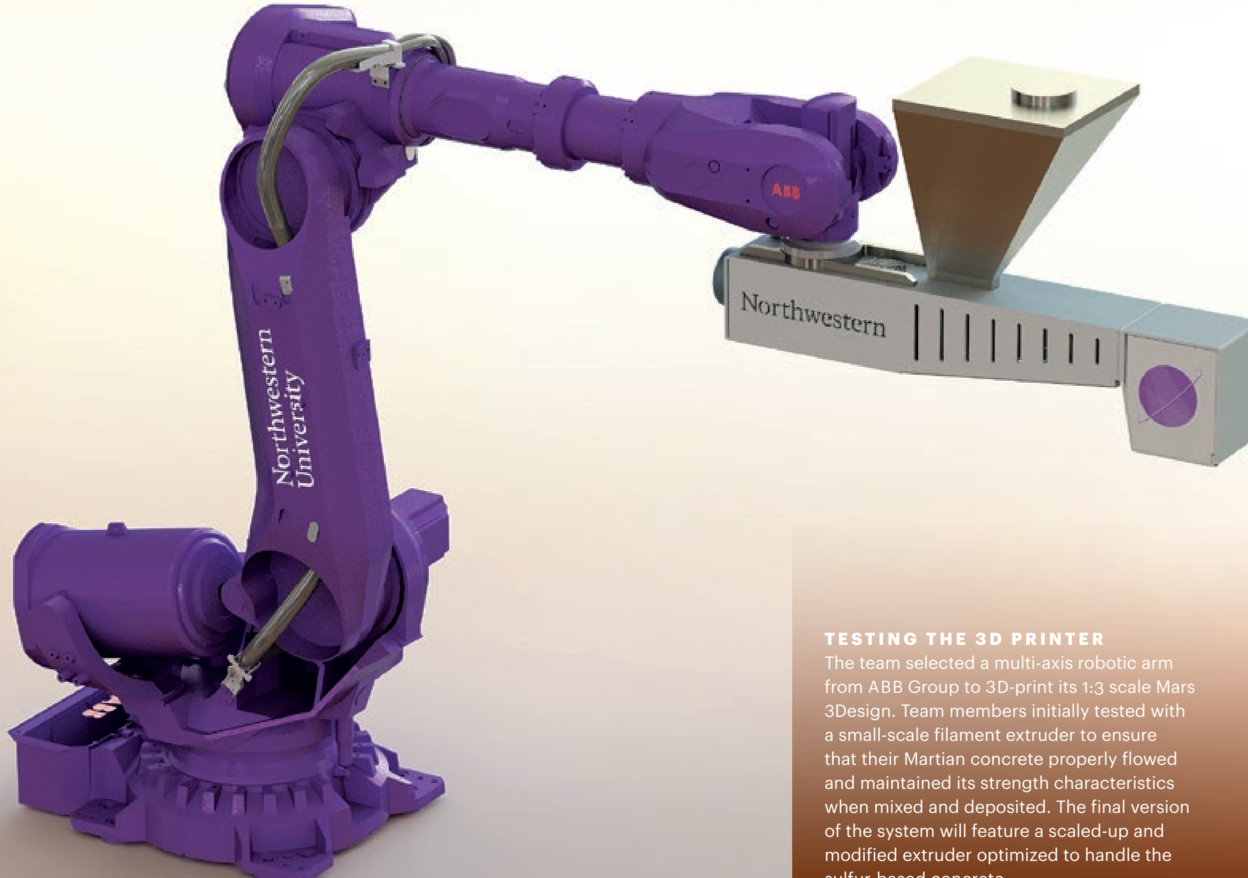
"Our design initially started with one main entrance, but after we were given requirements from NASA to include a rover hatch, we decided to make the whole habitat symmetrical," Troemner explains. "If we wanted to expand later on, not only would we have the rover hatch, which is required, but it could also accommodate a natural personnel hatch."

"The thought of building on Mars captures imaginations in a new way. It makes people listen. It's also an opportunity for us, as civil engineers, to showcase what we can do for our communities here at home."

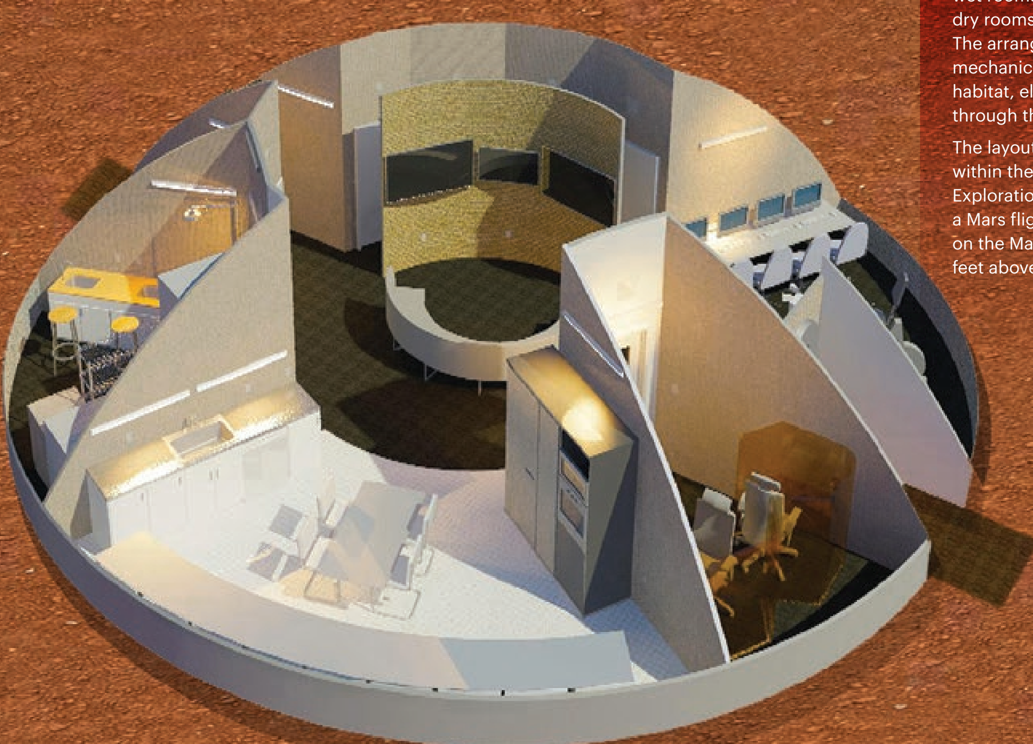
GIANLUCA CUSATIS
Associate Professor of Civil and Environmental Engineering

Image courtesy of Michael Goss

MARTIAN 3DESIGN'S OUTER SHELL
In designing the habitat's outer shell shape, the team met with Donna Jurdy and Seth Stein, professors in Northwestern's Department of Earth and Planetary Sciences, to brainstorm how 3D printing under Martian conditions would differ from Earth-based construction. The team's igloo-style design takes into account the planet's unique wind and gravity loads, as well as the potential for shifting sand dunes and meteorite impacts. "The outer shell acts as a kind of protective structure that is best suited for those loads," says Matthew Troemmer, PhD student.



TESTING THE 3D PRINTER
The team selected a multi-axis robotic arm from ABB Group to 3D-print its 1:3 scale Mars 3Design. Team members initially tested with a small-scale filament extruder to ensure that their Martian concrete properly flowed and maintained its strength characteristics when mixed and deposited. The final version of the system will feature a scaled-up and modified extruder optimized to handle the sulfur-based concrete.



INSIDE THE HABITAT
The team's interior design for the 1,000-square-foot Martian habitat separates the space's wet rooms, including the kitchen and lab, from dry rooms, like bedrooms and workstations. The arrangement consolidates plumbing and mechanical units to only one side of the habitat, eliminating excess materials running through the floors and walls.

The layout was inspired by the living quarters within the NASA-funded HI-SEAS (Hawaii Space Exploration Analog and Simulation) project, a Mars flight crew training simulator that sits on the Mauna Loa volcano approximately 8,200 feet above sea level on the Island of Hawaii.

MIXING THE RIGHT "MARSCRETE"
The team's Martian concrete recipe was inspired by previous research from Professor Gianluca Cusatis and Lin Wan-Wendner (PhD '15), a former student in Cusatis's lab. Cusatis and Wan-Wendner created Martian concrete by combining molten sulfur and NASA's JSC Mars-1A simulant, found on the cinder cone of a Hawaiian volcano. With JSC Mars-1A no longer available for testing, the team is using NASA's MMS-1 Mojave Mars Simulant, which possesses even greater mechanical and chemical similarities to dirt on the planet's surface.

The team also connected with Benton Johnson, associate at Skidmore, Owings & Merrill (SOM), one of the world's leading architectural design firms and a partner in Northwestern Engineering's MS in Structural Engineering program. Johnson guided the team through its design ideas, helping evaluate the loading conditions needed for a potential habitat to maintain structural integrity.

"SOM's structural expertise informed a habitat design that let us 3D-print over an inflatable pressure vessel, a structure that would be strong enough to support its weight if there was a loss of pressure in the habitat," Troemner says. "SOM also helped guide the overall shape and layout of our design."

The ingenuity paid off. In July, NASA announced that the Northwestern team earned fifth place and a share of the $100,000 prize in the Level 1 Virtual Design Challenge. Martian 3Design, one of only 18 submissions from around the world chosen to be judged by NASA experts, placed higher than any other university.

"We were ecstatic to learn of our placement," Troemner says. "The recognition was validation of our hard work up to that point and showed what Northwestern students are capable of doing."

NOW, TO BUILD IT

Any design relies on physical tools to bring its potential to life. That's why the team is focused on leveraging existing 3D-printing technology and Mars-local materials to make its habitat a reality. "We experimented to determine what combination of materials we could 3D-print consistently that also met the strength requirements defined by NASA," Troemner says.

The team developed a building concrete composed entirely of materials found on Mars or recycled components of the space-craft. Dubbed "Marscrete," the concrete combines sulfur—an element abundant beneath and within Martian soil—and NASA's MMS-1 Mojave Mars Simulant, a sand-like deposit obtained from the Mojave Desert that holds similar mechanical and chemical properties to the dirt surface of Mars.

Guided by research on injection molding machines, the group designed a robotic arm-based 3D printer to construct its habitat. The six-axis system is not only more cost-efficient compared to other 3D printers, but it can be prototyped with a modified filament extruder to deposit the sulfur-based Martian concrete.

To operate the printer, the dry materials are loaded into the 3D printer's extruder, where they are compressed and heated. The melted sulfur combines with the Mars simulant and is released as a paste, ready to be arranged into form by the robotic arm.

"The concrete hardens as strong as traditional casted concrete, but maintains properties that work well for 3D printing," Troemner says. "Most 3D-printed concretes have to be pre-mixed or pumped beforehand. This material is unique in that it can be loaded directly into the hopper."

MEANWHILE, BACK ON EARTH

If selected, the Martian 3Design team will travel to the Caterpillar Peoria Proving Ground in Peoria, Illinois, in April for the Habitat Challenge's culminating 3D-Printed Construction Competition. There, the team will use its 3D printer and Martian concrete to build a 1:3 scale model of the habitat envisioned in the Virtual Design Competition.

With NASA expected to announce the final competition's top three finishers, who will share an $800,000 prize, in spring 2019, the team's mission is nearly complete. But in many ways, according to Cusatis, the end is just the beginning. "Our hope has always been to build something that will live beyond the competition and afford us a chance to conduct more meaningful research in this new field," he says.

While large-scale 3D printing is undoubtedly part of NASA's plans to build its first human settlements on Mars, Cusatis believes these same technologies could jumpstart interest and innovation in a field that has long fought against it. "The thought of building on Mars captures imaginations in a new way. It makes people listen," he adds. "It's also an opportunity for us, as civil engineers, to showcase what we can do for our communities here at home."

ALEX GERAGE



WHAT'S YOUR TYPE?

Northwestern researchers sort through lots of data and find four personality types, challenging existing paradigm.

THAT SELF-CENTERED PERSON. THE ROLE MODEL. THE AVERAGE GUY. THE RESERVED ONE.

Throughout human history, people have tried to classify each other by describing personality types. The ancient Greeks described the four humors, a theory that personality results from a mixture of bodily fluids. Psychiatrist Carl Jung defined eight types, which Katharine Cook Briggs and her daughter Isabel Briggs Myers expanded into the 16 Myers-Briggs types.

Such descriptions may be used to help sort through job applicants or potential dates, but most researchers doubt that personality types even exist. "People have tried to classify personality types since Hippocrates's time, but previous scientific literature has found that to be nonsense," says William Revelle, professor of psychology at Northwestern University's Weinberg College of Arts and Sciences.

Northwestern Engineering's Luís Amaral and his colleagues challenge that paradigm in a new study. Sifting through data from more than 1.5 million questionnaires, his team found evidence for the existence of at least four distinct clusters of personality types—Average, Reserved, Self-Centered, and Role Model.

> "I like data, and I believe these results. The methodology is the main part of the paper's contribution to science."

WILLIAM REVELLE PROFESSOR OF PSYCHOLOGY, WEINBERG COLLEGE OF ARTS AND SCIENCES

The new research, published in *Nature Human Behaviour*, combined an alternative computational approach with publicly available data obtained from four questionnaires developed by researchers over decades: both the long and short versions of John Johnson's IPIP-NEO, the myPersonality project, and the BBC Big Personality Test datasets. "The questionnaires ask how strongly the respondent agrees with statements such as 'I get anxious when I have to meet new people,'" says Amaral, co-director of the Northwestern Institute on Complex Systems (NICO) and the Erastus Otis Haven Professor of Chemical and Biological Engineering.

"The thing that is really, really cool is that a study with a dataset this large would not have been possible before the web," Amaral notes.

Plotting the Types

From those datasets, the team plotted the five widely accepted basic personality traits—neuroticism, extraversion, openness, agreeableness, and conscientiousness. After developing new algorithms, four clusters emerged:

AVERAGE people are high in neuroticism and extraversion, while low in openness. Females are more likely than males to fall into the Average type.

RESERVED individuals are emotionally stable, but not open to new experiences. They are neither neurotic nor particularly extraverted, and are somewhat agreeable and conscientious.

ROLE MODELS score low in neuroticism and high in all the other traits. The likelihood that someone is a role model increases dramatically with age. More women than men are likely to fit the Role Models cluster.

SELF-CENTERED people score very high in extraversion and below average in openness, agreeableness, and conscientiousness.

During the initial research stages, the team, including Martin Gerlach, a postdoctoral fellow and the paper's first author, tried to identify psychologists with whom to collaborate. One name kept coming up—William Revelle. He specializes in personality measurement, theory, and research, but when the team approached him, he was skeptical of the study's premise.

Because previous attempts to classify personality types were based on small research samples, and the results often were not replicable, the concept of personality types remained in poor standing among psychologists.

The team's first attempt to sort the data used traditional clustering algorithms; that yielded inaccurate results. "At first, they came to me with 16 personality types, and there's enough literature that I'm aware of that says that's ridiculous," co-author Revelle says. "I believed there were no types at all." He challenged Amaral and Gerlach to refine their analyses.

In response, Amaral says, "We developed a new method to guide people to solve the clustering problem that performs a sanity test on the findings." The new algorithm first assumes that there are a large number of clusters and uses traditional methods to find them. Then, those clusters are winnowed down by imposing sanity check constraints. This procedure robustly identified four groups across the datasets.

"The data came back, and they kept coming up with the same four clusters of higher densities than you'd expect by chance," Revelle says. While he does not support the idea of distinct types, characterizing these results as showing "lumps in the batter," Revelle says, "I like data, and I believe these results. The methodology is the main part of the paper's contribution to science."

The research was funded by a gift from Mac and Leslie McQuown along with support from the US Department of Defense Army Research Office and the National Science Foundation.

To be sure the new clusters of types were accurate, the researchers used a notoriously self-centered group—teenaged boys—to validate their information. "We know teen boys behave in self-centered ways. If the data were correct and sifted for demographics, they would turn out to be over-represented in the Self-Centered cluster," Amaral says.

Indeed, young males are overrepresented in the Self-Centered group, while middle-aged females are vastly underrepresented. And good news for parents of teenagers everywhere: As people mature, their personality often changes. For instance, older people tend to be less neurotic yet more conscientious and agreeable than those under 20 years old.

"When we look at large groups of people, it's clear there are trends," Amaral says. "People may change some of their personality characteristics over time."

JULIANNE HILL

left to right William Revelle, Luís Amaral, and Martin Gerlach
Photographs by Sally Ryan

COMPUTER SCIENCE MOVES TO SEELEY G. MUDD BUILDING

NEW HOME ON THIRD FLOOR ENCOURAGES COLLABORATION, UNITES FACULTY IN ONE BUILDING.

Photographs by Sally Ryan

Computer Science at Northwestern Engineering is now in one unified space as the faculty moved into the Seeley G. Mudd Building in September 2018.

With inviting public areas, the 22,600-square-foot facility on the third floor of the newly enlarged building is designed to encourage intentional and spontaneous collaboration between faculty and students at the McCormick School of Engineering.

"Opening this new space is a key step in our plan to grow and transform Computer Science at Northwestern," says Julio M. Ottino, Northwestern Engineering dean. "Given the tremendous growth in student enrollments, increases in faculty hiring, and potential for new research that connects across campus, this new space will ensure continued excellence in CS."

Interest in computer science among students at Northwestern has grown significantly, with the number of computer science majors more than quintupling from 65 to 345 along with non-majors taking many advanced classes.

The building's unique features include:

PUBLIC SQUARE: a 1,638-square-foot common area for faculty, students, and visitors to relax and meet. Four breakout rooms and two open areas can be configured to meet a variety of groups' needs.

SEMINAR ROOM: a 1,143-square-foot area with seating for 48 people that can be configured for faculty meetings, lectures, and industry talks.

IDEA STUDIO: a 597-square-foot, six-sided gathering space which can be configured for a variety of meetings. The studio includes a sideboard, sink, and refrigerator for breakfast or lunch meetings.

INTEGRATED COLLABORATIVE SPACES: five workspaces, each about 250 square feet, that can be made public or private by opening or closing garage-style glass doors.

CONFERENCE ROOM: a 287-square-foot conference room that seats eight and features privacy glass that can go from transparent to opaque at the flick of a switch.

Previously, CS faculty offices were divided between the Technological Institute and Ford Motor Company Engineering Design Center.

JULIANNE HILL


1:47pm


Computer Science

Design Star

After a decade of expansion and growing influence, Design for America wins the prestigious Cooper Hewitt National Design Award.

> **“The jury was looking for organizations that could have this type of impact at scale. Because of its chapter network, Design for America can exert a reach and range of impact far beyond its size. It can activate more than a thousand talented, energized, diverse young people across the country. No other organization can do that.”**
>
> **DOUG POWELL**
> IBM Vice President of Designer Practices and Community

ON A HOT DAY DURING SUMMER BREAK, more than 100 college students from around the country gathered in small groups on Northwestern’s Evanston campus seeking answers from high school students and their teachers to important questions, such as:

- What stands in your way for receiving mental health services?
- What type of job would you like?
- Who is your role model?

The interviews, part of the 2018 Design for America Leadership Studio, were step one of a human-centered design process—gathering insights from community members, the potential users of the studio participants’ designs.

Those participants—themselves not so far removed from high school—were unified by the Design for America (DFA) mission to solve community-based problems using the human-centered design process. The goal of this year’s studio supplied the driving force: Empower teens to live their best lives by giving them support for mental health issues, access to mentorship, and preparation for future careers.

Meaningful work, national recognition

Like all DFA studios, this summer gathering featured interdisciplinary teams of students, faculty, and professional mentors from engineering, the natural and social sciences, and the arts. Launched in 2009 at Northwestern Engineering as an extracurricular organization, DFA now boasts a network of 38 college chapters in the United States, additional international clones, a robust and active alumni, mentor, and industry network, and a thickening portfolio of success stories and awards.

DFA’s growing impact on design worldwide earned it a prestigious 2018 National Design Award for Corporate and Institutional Achievement from the Cooper Hewitt, Smithsonian Design Museum. Launched at the White House in 2000, the annual awards program celebrates design as a tool in shaping the world.

With this honor, which is “bestowed in recognition of excellence, innovation, and enhancement of the quality of life” according to Cooper Hewitt, the group now takes its place among an esteemed list of previous winners, including Apple, Etsy, and TED. “Less than 10 years ago, three students and I were sitting on my office floor imagining the potential of Design for America, and today we are realizing the vision of this growing network with increasing impact,” says Liz Gerber, Northwestern Engineering associate professor of mechanical engineering and DFA’s faculty founder.

“To truly influence complex social issues like access to quality healthcare or climate change in a meaningful way, we need to engage large numbers of designers in a coordinated effort,” adds Doug Powell, IBM vice president of designer practices and community who served on the National Design Awards selection jury. “The jury was looking for organizations that could have this type of impact at scale. Because of its chapter network, Design for America can exert a reach and range of impact far beyond its size. It can activate more than a thousand talented, energized, diverse young people across the country. No other organization can do that.”

Capturing honors in the corporate and institutional category is humbling, of course, but also confirms that DFA’s work matters. “The award makes visible what the network sees each day and demonstrates that Design for America has something important to offer,” says Rebecca Breuer, DFA’s executive director since January 2016.

Building community

At the DFA Leadership Studio, student leaders attacked the challenge of empowering high schoolers using DFA’s curricular roadmap—understanding users, generating ideas, and rapidly building and iterating prototypes—to construct thoughtful, pragmatic, and scalable solutions.

In a spirited and animated manner, both purposeful and personal, the DFA teams used materials and tools ranging from Post-It Notes to cardboard to yarn to computer screens. One team developed an event where students could perform monologues or dances to express emotions about trauma. Another created an app matching mentors with mentees.

Photograph by Sally Ryan

Hannah Chung, Aaron Horowitz, Mert Iseri, Liz Gerber, and Rob Calvey accept the Cooper Hewitt Award.

This year's Leadership Studio was only one part of DFA's summer initiative, now known as the DFA Summit. The Create Impact Conference brought together devoted DFA alumni and young professionals to gain new tools for creating impact, while the invitation-only DFA Symposium challenged DFA mentors, design educators, and industry professionals to rethink how they can help shape the next generation of social innovators.

Empowering and motivating

"We bring people together under the shared belief that we can make changes now," DFA instructional coordinator Rob Calvey says. "And that's proven to be incredibly empowering and motivating."

Rather than give students final grades or course credit, DFA helps them develop personally and professionally and provides the satisfaction of crafting meaningful solutions to real-world problems. "It's a framework for innovation and positive societal impact," says Gerber, Charles Deering McCormick Professor of Teaching Excellence.

The students arrive with excitement, curiosity, and drive; faculty members, DFA mentors, and community partners provide the required expertise, guidance, and connections to help them grow through experimentation and iteration, even failure, on their path to a solution. "DFA is filled with like-minded people who want to use design skills to make the world better, who want to figure it out even when things get messy," stresses Breuer.

DFA's rapid evolution

It didn't take long for DFA to blossom from that group of three Northwestern students into the robust national organization Gerber envisioned. Within a year of DFA's founding—and spurred by the inaugural DFA team's Facebook progress reports and communication with peers at other institutions—Dartmouth College and Cornell University started DFA chapters. The following year, seven universities held DFA studios, and dozens inquired about establishing their own chapters.

With an eye on scale, Gerber spearheaded the creation of written tools, such as the *DFA Process Guide*, an online platform for project and studio management, and a professional mentor and partnership network to expand the DFA reach. These efforts were powered, in part, by seed funding from Northwestern Engineering Dean Julio M. Ottino that allowed Gerber to hire administrative personnel.

"This initial investment was critical for building the network," Gerber says of the support.

Empowered and motivated, DFA introduced a one-year fellowship program in 2010 that charged recent alumni to oversee network operations while simultaneously pursuing their own professional growth. A year later, DFA organized its first Leadership Studio.

That annual event draws DFA chapter leaders from across the United States to the Northwestern campus to sharpen their leadership skills and design processes. Previous years' studios focused on topics such as childhood asthma and urban flooding. "DFA is all about impact and improving the world around us through a network that's committed and engaged," Breuer says.

Continued momentum

In addition to fostering a new generation of social innovators, DFA has elevated its own profile on the design scene. With each passing year, the pace and scope of its impact grows thanks to the DFA model, which includes chapters, community partners, and alumni.

ACTIVELY ENGAGED CHAPTERS: The DFA national network of 38 chapters at universities such as Stanford, Yale, and Duke encompasses more than 1,200 students. Each year, DFA teams tackle more than 150 projects addressing topics such as homelessness, healthcare, and accessibility. More than 100 DFA faculty mentors provide crucial feedback on student work and facilitate connections with working professionals—architects, city planners, hospital administrators, and entrepreneurs—who share their perspectives and expertise and help extend DFA's reach into new corners of society.

ENTHUSIASTIC COMMUNITY PARTNERS: DFA enjoys a growing roster of community partners. This includes industry-leading enterprises, community agencies, and nonprofit organizations that have engaged with the DFA network to tap into its unique problem-solving perspective, usable insights, and prototyping capabilities.

For example, over the past five years, Fiat Chrysler has worked with various DFA studios on projects related to shared mobility, self-driving vehicles, and distracted driving. The automaker has elevated a number of those projects into its next round of internal consideration for implementation. The Open Doors Organization, a nonprofit focused on empowering people with disabilities, enlisted DFA's expertise to help ease air-travel challenges for power wheelchair users.

"The creative solutions our community partners see are the cumulative total of the problem-solving spirit that runs across the DFA network," says Calvey, who co-founded Virginia Tech's DFA studio in 2011 and joined the national office in 2013.

SPIRITED ALUMNI: The DFA alumni network, now nearly 2,400 strong, stretches around the globe. It includes architects, engineers, teachers, nonprofit directors, and more who bring their human-centered design mindset to such dynamic enterprises as Apple, Microsoft, SpaceX, and Tesla as well as to government agencies and higher education institutions.

A number of alumni have developed DFA-inspired programs beyond the United States, setting up training programs and design challenges in Taiwan, Pakistan, and China. For these international endeavors, DFA's national office provides support ranging from educational resources and alumni contacts to guidance on creating sustainable programs.

"Our alumni don't want to stop," Breuer says, adding that DFA is currently developing its first alumni board and a city ambassadors program. "DFA proves transformative for students and remains valuable as they transition to professional work. Alumni want to give back and help shape the next generation of social innovators."

DANIEL P. SMITH

Photographs by BFA

Harnessing the positive potential of artificial intelligence

TECH ENTREPRENEUR AND NOODLE.AI CEO **STEPHEN PRATT** IS USING DATA SCIENCE, SUPERCOMPUTING, AND MACHINE LEARNING TO RID THE WORLD OF WASTE.

Stephen Pratt ('84) wants to make the world a better place, and he believes artificial intelligence (AI) holds the key. As Noodle.ai chief executive officer, he's turning belief into action.

"What we're all about at Noodle.ai is using data science to eradicate the world's waste," says Pratt, whose interest in data science can be traced back to his undergraduate studies in electrical engineering at Northwestern Engineering. "If you look at all the waste in the global economy, both in the amount of materials that are consumed and the inefficient way they're used, it's a non-sustainable practice for the economy and the planet."

With the world population expected to reach 11 billion in the next century, it is a global priority to efficiently use natural resources and allocate goods, Pratt says, whether that means food, water, or steel. Noodle.ai executives are determined to solve these difficult issues with the help of the Beast, the company's sophisticated AI system that helps clients manage complex business operations and optimize decisions using algorithms and machine-learning tools.

This AI-as-a-service model has been incredibly successful for the two-year-old startup, earning it many accolades, including its recent number four ranking on LinkedIn's Top US Startups 2018, alongside firms like Lyft and Bird scooter. Based in San Francisco, Noodle.ai recently announced a $35 million round of funding from TPG Growth and Dell Technologies Capital. Clients include Big River Steel and private aviation platform XOJET.

Watching the company go from an idea about how to apply machine learning more effectively to a successful international business has been incredible, Pratt says. "Now we have 150 people in offices around the world who are doing tremendous good for our customers and saving many megawatt hours of energy and tons of natural resources and CO_2 emissions."

An eye for potential

Despite Noodle.ai's seeming overnight success, Pratt has worked on its underlying idea for years. Interested in control systems since his days at the McCormick School of Engineering, he used his skills serving in the Naval Reserve Officers Training Corps before joining Booz Allen Hamilton as a technology and strategy consultant. While working on satellite communications, he decided to earn a master's degree in the subject from the George Washington University.

He later joined consulting firm Deloitte, where he rose from entry-level partner to a top-level partner in just six years, the only person to have done so at the time. He began helping clients implement technology in customer relationship management, sales, and marketing with teams based in the US and India.

Seeing the potential for a globalized approach to technology consulting, Pratt approached Infosys about starting a consulting subsidiary. After getting the green light, he and frequent business partner Raj Joshi launched Infosys Consulting in 2004, going from a two-person startup to a company with 32,000 employees and $2.3 billion in revenue in 10 years. The company's success is the topic of case studies taught at Stanford University and Harvard University business schools, and Pratt has twice been named one of *Consulting Magazine*'s top 25 consultants in the world.

A new challenge

After a decade with Infosys Consulting, Pratt was ready for a new challenge. He connected with private equity company TPG Growth in 2014 about a new idea. "I thought the time had come for applying machine learning to complex businesses because the computing power was finally there," he says. "They hired me to go buy a company that was doing that. We looked for nine months and couldn't find it."

In the meantime, a friend from IBM asked Pratt if he was interested in running all of the Watson implementations worldwide for IBM Global Business Services. While the work was interesting, Pratt quickly realized that he wanted to work with a broader, more nimble technology.

He reconnected with TPG and crafted an agreement to fund the kind of company Pratt had in mind, a firm using both learning algorithms and business operational expertise to solve problems. He called up his Infosys Consulting collaborator Raj Joshi, and soon after, they launched Noodle.ai.

A better way to do good

Today, Pratt is right where he wants to be—heading up a company that uses artificial intelligence and machine learning to solve business problems. "What's really exciting about machine learning is that there are algorithms that learn and improve over time," he explains. "With traditional software, the day you put it in is the best it ever is—you put in fixed rules. With machine learning, the rules keep getting better, and they keep improving."

Clients subscribe monthly to use Noodle.ai's computing platform, which utilizes machine learning tools and algorithms to help them make their businesses more efficient and cut waste. XOJET increased profitability by using Noodle.ai's expert analysis to price flights better, while Big River Steel sold excess energy by predicting how much electricity it needed.

Noodle.ai's goal is to hit $100 million in revenue by 2020, but financial success isn't the only motivation. Pratt feels AI has great potential to improve our environment and society.

"There's a lot of hype right now about AI interacting directly with people or helping manipulate consumer decisions—I think that has the potential for real ethical issues," he says. "But applying AI to things like raw materials and manufacturing to reduce unnecessary inventory and eliminate waste has the potential to do tremendous good for the world and the global economy. At Noodle.ai, we're all about AI for good, and I think that AI technologies could hold the promise to solve a lot of the world's most complex problems."

A whole-brain engineer

Pratt's Northwestern roots are strong—it's where he met his wife, Edie, a neurosurgeon who studied in the Honors Program in Medical Education ('85, '87), and where his daughter, Abby, is currently a McCormick sophomore creating her own major in computer science and behavioral economics. He taught both Abby and his son, Adam, important lessons from Northwestern, like the importance of combining creativity and abstract thinking with technical knowledge to develop unique ideas. He endorses Dean Julio M. Ottino's whole-brain approach to engineering.

"That's at the core of what we do at Noodle.ai—we study cognitive biases in making decisions, and we can help people make better decisions," he says. "I think applying good core engineering principles while taking into account other disciplines is key to the future of engineering."

It's why he's happy to count many Northwestern alumni among the Noodle.ai staff. Pratt speaks on campus at The Garage and Kellogg School of Management as a way of giving back to the school that taught him engineering thinking. "McCormick really trained me how to think about complex problems and how to break problems down into solvable chunks in a methodical way," he says. "Those fundamentals and that blending of creativity and technology have helped me a lot in creating businesses."

SARA LANGEN

Photograph by Laura Morton

SAVING LIVES THROUGH BIOMEDICAL ENGINEERING

Medical technology innovator **Jenifer Kennedy** helps doctors perform pediatric surgery more safely and efficiently.

When Jenifer Kennedy (MS '89, PhD '91) decided to pursue her doctorate degree in biomedical engineering, Northwestern was only one of a handful of select schools with an entire biomedical engineering department.

"Biomedical engineering didn't exist when I was an undergrad," Kennedy says. "It sounded like something really new and interesting that would allow me to have a more positive impact with my career." Eventually, her post-graduate studies at the McCormick School of Engineering led to just that—the opportunity to develop technology that saves lives.

In her doctoral work, Kennedy studied the use of lasers for vision correction, specifically how energy reacts with tissue. "Studying at Northwestern is one of the smartest decisions I ever made," she says. "There was a lot of hands-on work. It was very application oriented."

After some post-doctoral study at Yale University, she launched her career in medical device product development, eventually landing at Valleylab, then a world leader in electrosurgery technology. There, her team created LigaSure, a technology that uses radio frequency energy to seal blood vessels.

"It ended up being a wildly successful technology," she says. Kennedy spent a year educating surgeons, presenting research to make them comfortable with using LigaSure in the operating room. It worked. LigaSure has become an industry standard.

Consistent with her desire to make a positive impact, Kennedy recognized a need for similar technology for the tiniest of patients. At that time, the only available options for surgery on children were high-powered, adult-sized instruments.

In 2010, Kennedy co-founded JustRight Surgical, focusing on vessel sealing in pediatric patients. "Honestly, doing that for the pediatric surgical community and their patients was probably one of the most rewarding things I've ever done as a biomedical engineer," Kennedy says. "We were getting phone calls, and people were saying, 'I could not have done this procedure without your device. You literally saved this baby's life today.'"

JustRight Surgical has grown to 35 employees, and its technology is used in more than 150 children's hospitals. The company has expanded its scope beyond pediatric care, including the development of a new product for use in robotically-assisted surgery.

Now living in Boulder, Colorado, Kennedy shows her gratitude to McCormick through her involvement in the Biomedical Engineering Advisory Board. "It's fun to interact with the faculty. They've been so receptive to suggestions and are constantly working to improve the department and its program offerings," she says. "It's a great group."

ALEXANDRIA JACOBSON

Material Motivation

WITH HER SIGHTS SET ON THE C-SUITE, **CYNTHIA PIERRE** HOPES TO INSPIRE THE NEXT GENERATION OF LEADERS.

If you only went by what she wrote in her high school yearbook, you'd think Cynthia Pierre's (PhD '09) life has followed a clearly defined path.

It was there that her teenage self laid out a singular plan: become an industrial chemical engineer. After getting her PhD in materials science and engineering at Northwestern Engineering in 2009, that is exactly what she did.

But as a young girl growing up in Miami, Florida, the daughter of Haitian immigrants who did not attend college, Pierre could not imagine such a future for herself. Fortunately, a high school physics teacher saw Pierre's innate talent for science and nominated her for a NASA Summer High School Apprenticeship Research Program, an eight-week program that drew high school students from across the country to conduct research at NASA facilities and universities. There, she began to understand what engineering was.

"The program combined everything I loved—calculus, physics, chemistry," she says. "I realized that if I wanted to be a researcher, I needed to get a PhD."

After earning a chemical engineering degree from Princeton University, Pierre began graduate study in the lab of John Torkelson, Walter P. Murphy Professor of Chemical and Biological Engineering and Materials Science and Engineering in the McCormick School of Engineering. For her work on solid-state shear pulverization, Pierre received the Dow Sustainability Innovation Student Challenge Award, given to students who offer sustainable solutions to the world's most pressing environmental problems.

Perhaps most importantly, she says, she learned how to think about problems innovatively and to communicate her results to different audiences. "I learned a lot of discipline in Professor Torkelson's lab and how to work effectively in a group on collaborative research," she says. "Those are skills I've used throughout my career."

After completing her PhD, she spent five years at Dow Chemical in Midland, Michigan, synthesizing polymers for semiconductors, developing biorenewable cleaning agents, and creating new dispersants for heavy-duty engine oils. While there, she garnered four patents.

Though Pierre found the work at Dow collaborative and interesting, when she learned about BP's Future Leaders Programme, a four-year program to develop promising young professionals, she knew it was her chance to take her career to the next level and work abroad. Her involvement with Future Leaders led to a stint at a refinery in Western Australia and ultimately to her current position as inspection, materials, corrosion, and engineering superintendent at BP's refinery in Cherry Point, Washington.

Now, as a leader rather than a researcher, her job is to motivate her employees and act as their advocate—something she would like to continue doing on a higher level. "I would love to make it to the C-suite," she says. "There aren't very many women, not to mention black women, who hold those types of executive positions. I could potentially inspire others to pursue their dreams."

Many would say Pierre has already done that. She spends much of her time mentoring STEM students and serves on Northwestern's Materials Science and Engineering Advisory Board. She even inspires others through her mother, who tells the guests at the hotel where she works all about her successful, world-traveling daughter.

"It's great," Pierre says of her mother's delight. "She's so proud."

EMILY AYSHFORD

From Nepal to New York, Alum Innovates Water Solutions

Pam Elardo works to optimize New York City's aging wastewater system while enabling and empowering women around the world.

When someone flushes a toilet in New York City, that wastewater enters a vast 7,400-mile network of pipes, passing though 96 wastewater pump stations and ultimately ending up at one of 14 wastewater resource recovery facilities that produce clean water and valuable by-products.

For a city of 8.5 million residents who together send 1.3 billion gallons of water a day down the pipes, all of that is an important but hidden operation.

Managing the entire process requires a special mix of expertise and skill: the engineering experience and know-how to optimize the system and the managerial and people skills to articulate the mission and to motivate employees to fulfill it.

That's an enviable combination for any engineer in a leadership position. But for her tenacity and the support of progressive mentors, the woman now at the helm of the Bureau of Wastewater Treatment, deputy commissioner Pam Elardo ('83), most likely would never have become an engineer, much less one with such responsibility and authority.

A new wave of female engineers

Growing up in Addison, Illinois, in the 1970s, Elardo was interested in environmental science and had a sense of what it meant to be an engineer, but she did not know anyone else in her high school class who wanted to study engineering.

"There weren't a lot of people in my high school who went to college," she says. "And from male teachers and advisers, I heard a lot of things like, 'Oh, you can't be an engineer because it's a man's job.'"

Undeterred, she applied to Northwestern to study chemical engineering. There, she became part of a new wave of young women interested in the field. Still, she faced obstacles, including one in the Technological Institute, which ironically related to her eventual field of work.

"There weren't many bathrooms for women in Tech," she says. "If I had to go, I had to walk all the way across the building to where the secretaries sat."

Times have changed. This year's freshman class at the McCormick School of Engineering is 38 percent female.

Despite the challenges, Elardo found research opportunities through Professor George Thodos, who provided clear mentorship. She also found a special niche with the Northwestern women's basketball team, which achieved Big 10 conference championships and made it to the NCAA national tournament during her years on the squad.

"Because of the time I had to spend at practice and games, I learned to study really efficiently," she says. "And I learned good discipline."

Designing water systems for villages

When she graduated in 1983, Elardo put her engineering skills to use right away as a Peace Corps volunteer in Nepal. For a young woman who had never been outside the United States, arriving in a small, remote Nepalese village without electricity was eye opening, to say the least. She had to travel to Kathmandu—about 150 miles by foot and bus—just to call her mother, which she did twice a year.

Once in the country, she quickly got to work designing and constructing gravity-fed water supply systems for several villages that had no clean water source nearby. Designing these systems was especially important to her because often it was the girls who spent their days traveling to and from water sources instead of going to school.

"I saw the impact of my work almost immediately," she says. "I would design something, and the next year I would construct it. It was so important for the health and well-being of women and girls."

Returning to the United States in 1986, she landed a job as an environmental engineer in the Washington State Department of Ecology in Seattle, helping to implement regulations related to the Clean Water Act. Over the next 15 years, she moved up within the organization, earning her master's degree in environmental engineering at the University of Washington along the way.

In 2001, she joined Washington's King County Wastewater Treatment Division, moving from regulation to implementation of technologies to create better environmental outcomes. There, she learned capital planning, permitting, and asset management, eventually ran the West Point Treatment Plant, the largest in the state, and then became the director of the entire division.

Along the way, she never forgot her time in Nepal. She co-founded the nonprofit Living Earth Institute, which raises money to build water supply and sanitation systems in developing countries.

Bigger systems, bigger opportunities

In 2016, Elardo moved into her current role, where she found herself dealing with a much bigger, older system. New York City built its first wastewater treatment facilities in the 1890s, and Elardo was anxious to bring in experience with new technology and optimizing processes to reduce greenhouse gases and make the business more sustainable.

"There's a million things to do," she says. "The least thing I am is bored."

Throughout her career, Elardo has continually provided mentorship to the next generation of female engineers, both in the United States and abroad, in hopes that young women don't face the obstacles she did. "There's a myth," she says, "that because engineering can be challenging, and if you're a woman, you'll have a hard time. Now with a few generations of women in the field, you can find mentors. And if you feel comfortable with math, you'll be fine, and the opportunities engineering presents worldwide are really, really amazing."

EMILY AYSHFORD

DATA MAN

BLENDING AN INTRINSIC CURIOSITY WITH A MCCORMICK EDUCATION, **GREG MCKINNEY** CONTINUES HELPING BUSINESSES TURN DATA INTO ACTION.

"At Northwestern, I was challenged to really dig into the data and to extract insights, draw conclusions, and take action."

As a perpetually curious kid in Glenwood, Illinois, who carried a slide rule in his pocket, Greg McKinney (MS '81) inspected and dissected everything from lawnmowers to worms. Data coupled with a keen eye provided a window into discovery.

Blending that intrinsic curiosity with concepts and techniques he learned during his graduate studies at Northwestern Engineering, McKinney has since spent the better part of four decades as a data scientist helping a diverse array of companies craft a more productive, stable future.

"I've always loved digging down and finding hidden gems in the data because I know somewhere in there is knowledge," McKinney says. "Some people think about analytics in terms of terabytes of data, but I'm wondering how the data can inform the business."

Such inquisitive, analytical work often means challenging conventional wisdom.

In 1981, for instance, after McKinney left the McCormick School of Engineering to enter the energy sector with Occidental Petroleum, the firm's executives wanted a tool to better assess international exploration strategies. McKinney developed a model to evaluate these always expensive and precarious endeavors, and his results ran counter to the firm's existing strategy. He suggested newfangled alternatives and had to use persistence and creativity to convince Occidental's leaders of his work's validity. Ultimately, his new methods spurred productive results.

"Getting into the data can lead to some pretty radical ideas, so you better have confidence and conviction in your work because ideas that challenge the status quo are likely to come under attack," McKinney says.

In later career stops at Bank of America, Charles Schwab & Company, and Kaiser Permanente, McKinney's analytical work championed new approaches that altered operations and sparked heightened performance. "There's great satisfaction when the models developed change thinking and the way the company operates," says McKinney, now an independent consultant to large healthcare organizations.

Reflecting on his career, McKinney credits his studies in industrial engineering at McCormick with providing the technical knowledge, tools, and theory to transform a curious kid into a business-driving professional. "A lot of people talk about data analytics, but it's shallow: Divide this number by that number," he says. "At Northwestern, I was challenged to really dig into the data and to extract insights, draw conclusions, and take action."

Now living in San Francisco, McKinney remains actively engaged with McCormick, serving as national chairman of the Walter P. Murphy Society, a group of donors who advise Dean Julio Ottino about funding decisions for faculty- and student-initiated projects ranging from integrating new curriculum elements to purchasing specialized equipment.

"The Murphy Society represents a level of donor engagement rare in higher education," McKinney says. "That openness is what I love about McCormick and what makes it a special place."

DANIEL P. SMITH

IN MEMORIAM

Professor Emerita Julia Weertman

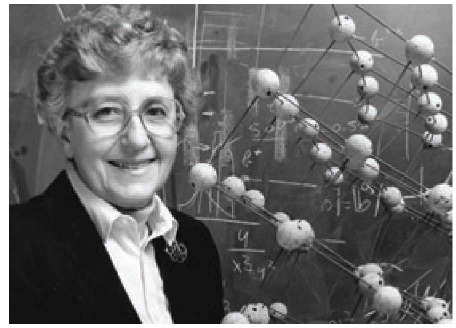
Julia R. Weertman, Walter P. Murphy Professor Emerita of Materials Science and Engineering, passed away at age 92 on July 31.

Weertman made noteworthy contributions to understanding the basic deformation processes and failure mechanisms in a wide class of materials, from nanocrystalline metals to high-temperature structural alloys. Her 1964 textbook, *Elementary Dislocation Theory* (Reprint, Oxford University Press, 1992), which she co-authored with husband Johannes Weertman, stands as the first book written for undergraduate students on dislocation theory, an important factor in determining the behavior of crystalline materials.

She was the first woman admitted to the College of Science and Engineering at the Carnegie Institute of Technology, where she earned her bachelor's, master's, and DSc degrees in physics. She joined Northwestern in 1972 as assistant professor of materials science, teaching courses at both the undergraduate and graduate levels.

In 1987, Weertman was appointed chair of the Department of Materials Science and Engineering, becoming the first woman in the country to hold the position within an engineering department.

In 2014, she received the prestigious John Fritz Medal from the American Association of Engineering Societies in recognition of her role in the understanding of failure in materials and for inspiring young women to pursue careers in engineering. Her other honors include membership in the American Academy of Arts and Sciences and the National Academy of Engineering.



"In Julia and Johannes, Northwestern Engineering had two impressive educators and researchers who set a high bar for their department. We are forever grateful that they shared their work, expertise, and lives with us."

JULIO M. OTTINO
Dean of Northwestern Engineering

Professor Emeritus Johannes Weertman

Johannes Weertman, Walter P. Murphy Professor Emeritus of Materials Science and Engineering, passed away at age 93 on October 13.

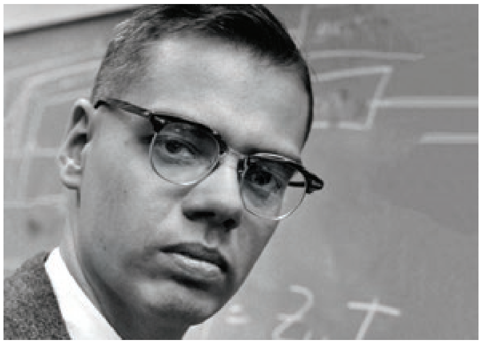
Weertman made many contributions to the study of the mechanical properties of materials, particularly to the fatigue and fracture of metals, high-temperature creep of crystalline solids, and dislocation theory.

He attended the College of Science and Engineering at the Carnegie Institute of Technology, where he earned his bachelor's and DSc degrees in physics. Following graduation, he worked at the US Naval Research Laboratory, where he studied glacier flow and ice sheets. His research contributions were honored by the United Kingdom Antarctic Place-names Committee, which established "Weertman Island" in 1960, a 3.5-mile-long island off of the Antarctic coast.

A member of the American Academy of Arts and Sciences and the National Academy of Engineering, Weertman joined Northwestern in 1959 as associate professor within the newly formed Department of Materials Science. He served as chair of the department from 1964 to 1968.

In 2014, the Department of Materials Science and Engineering established the Johannes and Julia Randall Weertman Graduate Fellowship in honor of the couple's contributions to materials science at Northwestern. In 2017, The Minerals, Metals & Materials Society renamed its TMS Educator Award to the TMS Julia and Johannes Weertman Educator Award, celebrating outstanding contributions to education in metallurgical engineering and/or materials science and engineering.

IN MEMORIUM



PROFESSOR EMERITUS JAMES AAGAARD

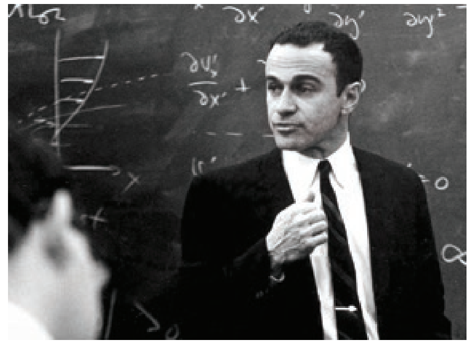
James Aagaard, professor emeritus of electrical engineering and computer science, passed away at age 87 on June 22, 2018.

A native of Chicago's Rogers Park neighborhood, Aagaard arrived to Northwestern as a first-year student in 1948, then spent the following 63 years as a student, faculty member, and academic researcher. He received his bachelor's, master's, and PhD degrees in electrical engineering from the McCormick School of Engineering and Applied Science and joined the school's faculty as an assistant professor in the Department of Electrical Engineering in 1957.

In 1968, Aagaard was tasked to develop a new system to organize and track the circulation of the library's more than 1 million books and materials. Aagaard created the Northwestern Online Total Integrated System (NOTIS), the school's first online library cataloging system.

Launched in 1970, NOTIS quickly influenced how libraries around the world managed their collections, with more than 100 institutions, including some of the largest US research libraries, using NOTIS at its peak. In 1985, Aagaard received the LITA/Gaylord Award for Achievement in Library and Information Technology from the American Library Association.

After Northwestern sold NOTIS to telecommunications company Ameritech in 1991, Aagaard remained with the University as an assistant University librarian. In 2007, he and his wife, Mary Lou Aagaard, received The Deering Family Award from Northwestern Libraries. He retired in 2011.



PROFESSOR EMERITUS ARTHUR KOVITZ

Arthur Kovitz, professor emeritus of mechanical engineering, passed away on April 30, 2018, at age 89.

A native of Detroit, Michigan, Kovitz earned his bachelor's degree in engineering physics and master's degree in physics from the University of Michigan. After spending a year as a research engineer at Bell Aircraft Corporation in New York, he returned to school and received his PhD in aeronautical engineering from Princeton University. In 1958, he joined Northwestern's Department of Mechanical Engineering and Astronautical Sciences as an assistant professor.

Kovitz's research interests focused on "soft mechanics," with an emphasis on fluid mechanics and interfaces, combustion, and heat transfer in aircraft and rocket engines. He published more than two dozen papers and introduced several new department courses that explored topics within thermodynamics, aerodynamics, and kinetic theory.

Along with serving as chair of the Department of Mechanical Engineering and Astronautical Sciences from 1971 to 1973, he served on the Tech Thermodynamics Committee, the Tech Curriculum Committee, the Tech Fluid Mechanics Committee, and the University's Science-Engineering Council.

His honors include a nomination for Northwestern's Tech Teaching Award in 1976. He was also a member of the American Institute of Aeronautics and Astronautics, the American Physical Society, The Combustion Institute, and Tau Beta Pi. He retired from teaching in 2001 after more than 40 years at Northwestern.

Douglas R. Aldrich '43
Stanley O. Erickson '44
John E. Christ, Jr. '46
John W. Cox '46
Lewis A. Souders '46
Richard Vandenberg, Jr. '46
Arthur J. Conley '47
Charles E. Thorney, Jr. '47
William McGaw '48
Richard H. Golterman '49
Jack E. Kunze '49
James A. Stallwood '49
Charles H. Fox '50
Richard H. Godfrey '50
Charles S. McNeer '50
William K. Miller '50
Ross R. Calvin, Jr. '51
Thomas R. Johnson '51
John H. Lundell '51
Herbert Malin '51
Harold F. Klock '52, '54, '56
James S. Aagaard '53, '55, '58
Gordon C. Ebling '54
George F. Steiner '54
Jack S. Divita '55
Robert W. Volkmann '55, '68
Leslie R. Inglis '56
Robert G. Garrigues '57
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John A. Smith '58
William C. Trotter '58
E. Philip Dahlberg '59, '61
Norman A. Jacobs '59
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James B. Forrest '66
Robert Y. Lai, '67, '69
Anthony Robert Kane '69
Lawrence A. Semenza '71, '72
Kathleen R. Flaherty '73, '75, '79
Thomas M. Campbell, III '74
G. Scott Rutherford '74
Gary J. Grosicki '80
Cecilia Cicchinelli '81
Sarkis Tatioussian '82
Stephan E. Kolitz '83
Charles Stewart Smith '97, '97
Wan-Lin Chen '99

BIG IDEA

SELF TRANSFORMATION

Northwestern researchers have developed soft materials that autonomously self-assemble into molecular superstructures and remarkably disassemble on demand. Changing the properties of materials opens the door for novel materials in applications ranging from sensors and robotics to new drug delivery systems and tools for tissue regeneration.

For example, the highly dynamic materials form hydrogels, and provide unexpected biological clues about the brain micro-environment after injury or disease, when their superstructures reveal reversible phenotypes in brain cells characteristic of injured or healthy brain tissue.

The study's co-corresponding authors are Samuel Stupp, director of the Simpson Querrey Institute and the Board of Trustees Professor of Materials Science and Engineering, Chemistry, Medicine, and Biomedical Engineering, and Erik Luijten, Professor and Chair of Materials Science and Engineering and Engineering Sciences and Applied Mathematics.

Image by Ming Han and Erik Luijten

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FIND THAT BLOCK!

Two undergraduate students set up their autonomous robots during Northwestern's 27th annual Design Competition held at the Ford Motor Company Engineering Design Center in May. With cash prizes at stake, eight robots—many with GPS location tracking—battled it out during a game of "Find that Block!" The event challenged the machines to find steel shapes scattered throughout the arena. Student teams with members from a variety of engineering fields spent five months designing, building, and programming their robots.

Photograph by Joel Wintermantle