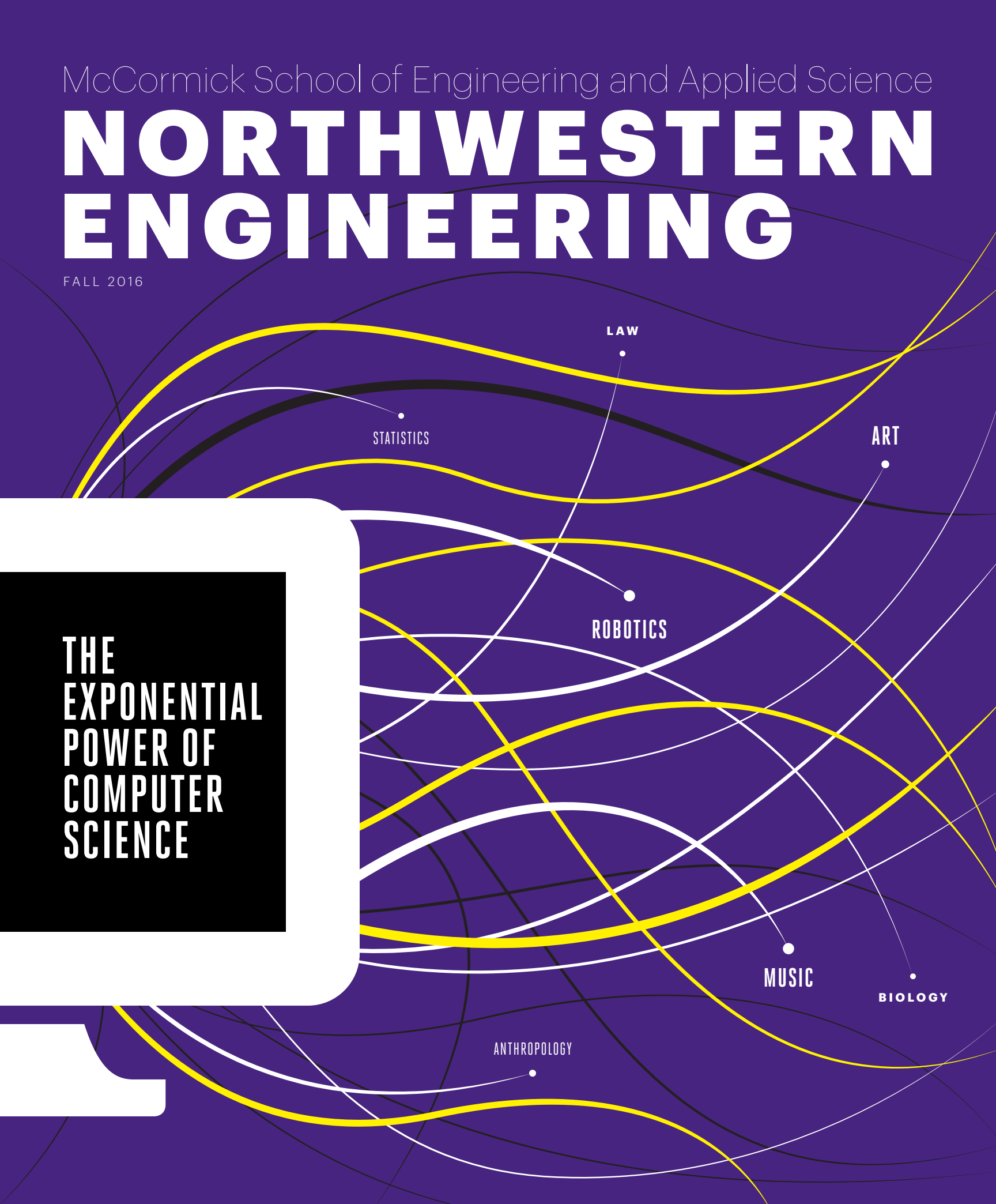
McCormick School of Engineering and Applied Science

NORTHWESTERN ENGINEERING

FALL 2016



THE EXPONENTIAL POWER OF COMPUTER SCIENCE

GET OUT THE VOTE

More than 100 students visited Northwestern in August for the seventh annual Design for America Leadership Studio. With the 2016 presidential election campaigns in full swing, the event challenged students to use human-centered design to develop solutions for improving voter experience. Proposed solutions included a sticker book to educate and excite children about elections, an app to simplify the voter registration process, a community action network to spread information at the grassroots level, and a community conversation table to inspire civic discussions. Participants came from 33 universities nationwide, including MIT, Cornell, Brown, Stanford, and Yale. Read more on page 5.

Photograph by Sally Ryan


DESIGN for AMERICA
LEADERSHIP STUDIO
2016
Northwestern
ENGINEERING
WITH SPECIAL THANKS TO:
THE BLAKE FAMILY
3M

"THE GOAL IS TO NOT ONLY ADVANCE COMPUTER SCIENCE AT NORTHWESTERN, BUT ADVANCE NORTHWESTERN THROUGH COMPUTER SCIENCE."

GREETINGS FROM NORTHWESTERN ENGINEERING

This summer, the University announced a major investment in Computer Science. Recognizing that the field has become a foundational discipline for many of our students, and that faculty across departments are increasingly using computational thinking in their own disciplines, the University will hire an additional 20 Computer Science faculty members in the coming years. The goal is to not only advance Computer Science at Northwestern, but advance Northwestern through Computer Science.

What is perhaps most interesting is that half of the new faculty members will be in core Computer Science areas and half in collaborative "CS+X" appointments with other disciplines. We are currently developing the strategic framework, and the possibilities are endless. Computer Science has the potential to connect and amplify nearly every field at the University. We look forward to recruiting the best collaborative computer scientists to help make this happen, and we will keep you updated on our progress.

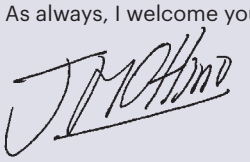
In recent years, our Computer Science faculty members have connected more with our Department of Industrial Engineering and Management Sciences (IEMS) faculty members. IEMS has considerable strength in optimization and machine learning. The Center for Optimization and Statistical Learning will create new research connections and leverage optimization principles in areas as varied as search engines, power grids, and organ donations. I hope you will read more about this field on page 18.

This fall, we welcomed new faculty member John Rogers (page 28), a bioelectronics pioneer whose bendable, flexible electronics can be integrated within the human body. His work has the potential to change the fields of industrial and consumer electronics. He will lead the new Center for Bio-Integrated Electronics in the Simpson Querrey Institute for BioNanotechnology.

Our work in biomedical technology extends to the developing world through our Center for Innovation in Global Health Technologies (CIGHT) (page 22). For more than a decade, the Center has worked to develop low-cost, easy-to-use tests for HIV, tuberculosis, and hepatitis C. With corporate partners and through the Northwestern Global Health Foundation, CIGHT researchers have worked to bring these tests to market through nonprofits. They hope to help solve one of our most pressing problems by giving patients in developing countries access to better healthcare.

Finally, I hope you will read about several of our interdisciplinary student projects in our Ideas at the Intersection feature (page 36). These are just a sample of the projects we highlight on the website (ideas.northwestern.edu) and show the wealth of innovations that happen when students come together across fields through courses, student groups, and self-assembled teams.

As always, I welcome your feedback.



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

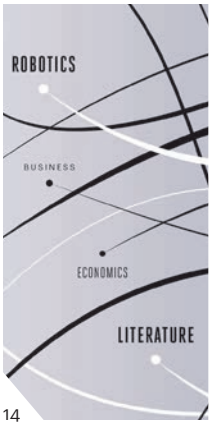
On the Cover

The University will add 20 full-time computer science faculty members, half in core computer science areas and the other half as collaborative CS+X appointments. See story on page 14.

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

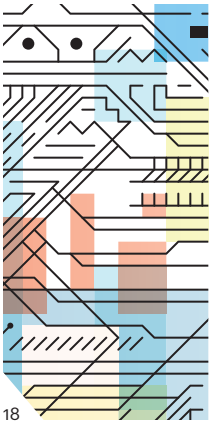
Northwestern | McCORMICK SCHOOL OF ENGINEERING

Director of marketing: Kyle Delaney
Managing editor: Emily Ayshford
Produced by The Grillo Group, Inc.



14

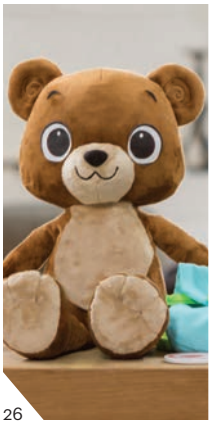

28


18


32


22


34


26


36

NEWS

FAST COMPANY FEATURES STUDENT DESIGN ALTERNATIVES TO IKEA DRESSERS

Ikea's recall of 29 million Malm dressers has drawn renewed attention to the risk of accidents and injury when children climb on furniture. Consumers have been told that one way to prevent such accidents is to secure their dressers to a wall. Working with Kids in Danger and Shane's Foundation, freshmen in the Design Thinking and Communication course designed their own dressers that improve on Ikea's recalled model without having to secure them to a wall. Their final mock-ups were recently featured in *Fast Company*.

One project, SafeSlant, shifted the dresser's center of gravity while limiting how far out the dresser drawers could be extended. Another solution, the Safe Shelves system, does away with drawers completely, opting instead for a set of rotating shelves within a frame that uses a wide base to prevent tipping.

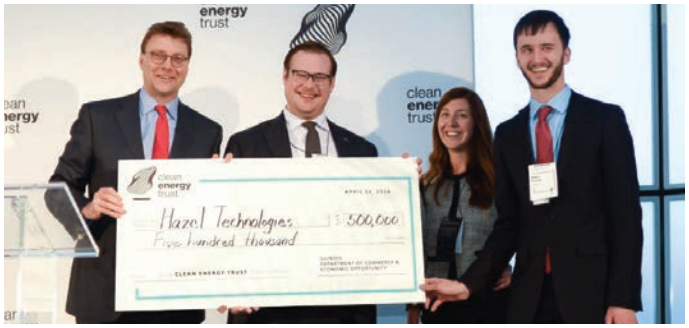
"We need a dynamic partnership between law and engineering, a constant dialogue to think of questions about the application of law to new technology and the impact of new technology on law."

DEAN JULIO M. OTTINO

DEANS CALL FOR ENGINEERING AND LAW COLLABORATION

In a May 2016 op-ed in *The Chronicle of Higher Education*, Northwestern Engineering Dean Julio M. Ottino and Pritzker School of Law Dean Daniel B. Rodriguez argue that rapid advances in technology should encourage engineers and lawyers to bridge the gap between the two disciplines. For lawyers, that means collaborating with engineers early in the innovation process by offering expertise on ethical considerations and legal precedent. Conversely, engineers must make an effort to understand the law's role in clarifying engineering goals.

Ottino and Rodriguez both see universities as a gateway to strengthened collaboration between engineering and law. They cite as an example Northwestern's NUvention experiential learning courses that bring together students from different disciplines and academic backgrounds.

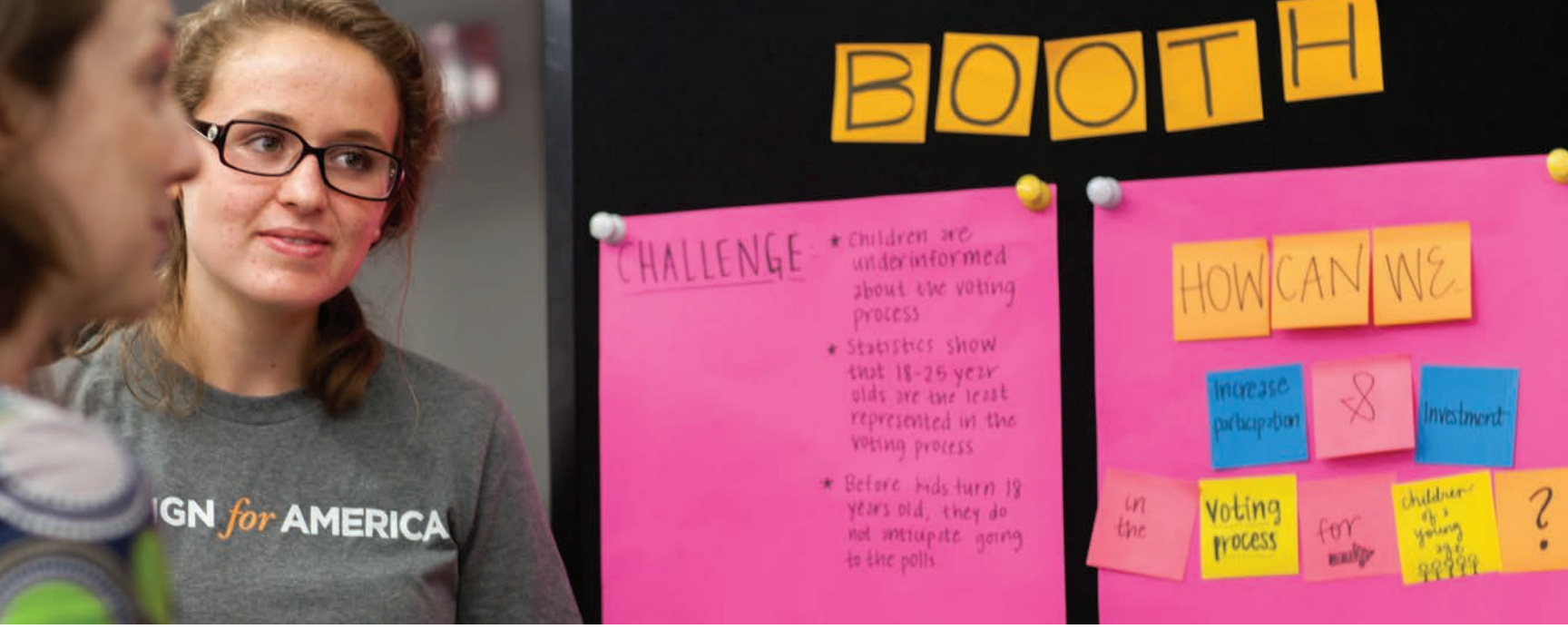


NORTHWESTERN SPINOUT COMPANY TAKES HOME TOP PRIZE AT CLEAN ENERGY TRUST

Hazel Technologies received the Clean Energy Trust's sixth annual Clean Energy Challenge $500,000 grand prize for its FruitBrite™ technology, which extends the shelf life of produce, flowers, and plants by up to 400 percent. The company was spun out of NUvention: Energy, a clean tech commercialization course sponsored by the Farley Center for Entrepreneurship and Innovation and the Institute for Sustainability and Energy at Northwestern. Hazel Technologies also took home the Illinois Clean Energy Fund Award and will use the funding for technology optimization and full commercialization of the product.

STUDENTS LEARN TO COMBAT HACKERS

In winter quarter 2016, adjunct lecturer and forensics practitioner Jibran Ilyas and Professor Yan Chen paired up to create and teach EECS 395: Digital Forensics and Incident Response. The class taught students how to investigate digital artifacts and preserve and analyze data left on hard drives, logs, and other network devices. Students also learned about different types of attacks, including cybercrimes and state-sponsored attacks, and how to combat them.



Using Design to Improve the Voting Experience

The seventh annual Design for America (DFA) Leadership Studio welcomed 110 students from 33 universities to learn about design, social innovation, and creative leadership. This year's studio specifically challenged students to use human-centered design to improve the voting experience and to present their voting experience solutions at a design expo attended by business professionals, design experts, and DFA staff and alumni.

One team presented Youth to Booth, a program that aims to inspire civic engagement in children by challenging them to collect stickers in a booklet. When children learn a piece of information about government or the voting process, they collect a sticker embedded with a QR code coupon that their parents can use at local sponsoring businesses. The booklet's last sticker is collected at the actual voting booth.

"If children are excited about the voting process earlier in life, they will come back to vote when they are 18," said Claire Quinlan, an undergraduate at Washington University who worked on the project.

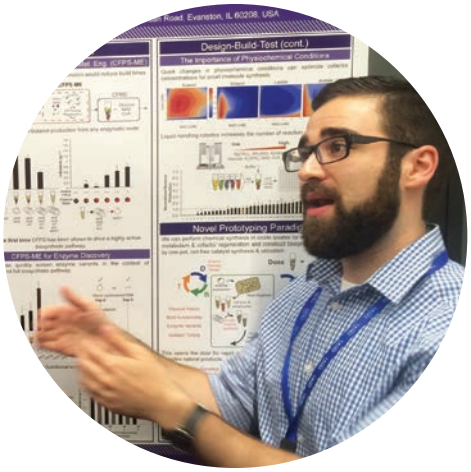
Other DFA projects to help improve the voting process included an app to simplify voter registration, a community action network to help spread knowledge about elections and candidates at a grassroots level, an app to help voters learn about their districts to prepare for local elections, and a community conversation table to inspire civic discussions.

"THE EXPERIENCE WORKING WITH A BASF COMMUNICATION COACH TAUGHT US TO CRAFT PRESENTATION MATERIALS THAT WERE SIMPLE AND TO-THE-POINT. WE TAILORED OUR PITCH TO THE JUDGING PANEL IN AN EASY TO UNDERSTAND WAY THAT DIDN'T LOSE ITS EFFECTIVENESS OR IMPORTANCE." **DAVID PICKENS** PHD STUDENT

PHD TEAM WINS BASF SCIENCE COMPETITION

Mechanical engineering PhD students Blake Johnson, Jie Lu, and David Pickens and chemistry PhD student Michael Desanker won BASF's nationwide science competition, which challenges young researchers to come up with solutions to a major global issue. Professors Q. Jane Wang, Yip-Wah Chung, and Tobin Marks advised the team.

This year's competition asked teams to develop a synthetic fluid that meets the performance requirements for high-efficiency vehicles. The Northwestern team's solution attached borate ester compounds to the double-bonded area of polyalphaolefin (PAO) oligomers found in a synthetic lubricant's base oil. The treated PAO oligomers were then combined with untreated PAO oligomers and additives to form a mixture that is optimized for lubricant-based uses.



NORTHWESTERN SHINES AT INTERNATIONAL SYNTHETIC BIOLOGY CONFERENCE

Northwestern engineers celebrated multiple wins at the 2016 Synthetic Biology: Engineering, Evolution, & Design (SEED) conference in Chicago. Chaired by Professor Michael Jewett, the event focused on designing, harnessing, and expanding the capabilities of biological systems.

During the event, Professors Danielle Tullman-Ercek and Keith Tyo discussed their latest work, and students of Professors Josh Leonard and Jewett delivered their research in posters and rapid-fire talks. Amidst all the events, Professor Julius Lucks received ACS Synthetic Biology's 2016 Young Investigator Award.

150

Number of CubeSats (miniature satellites) launched to date. Northwestern students will launch a freeze-casting experiment in a CubeSat to low-Earth orbit next year.

FARLEY CENTER TEACHES AFRICAN LEADERS ENTREPRENEURSHIP SKILLS

This past summer, the Farley Center for Entrepreneurship and Innovation and Northwestern's Program of African Studies hosted 25 fellows in the US government's Young African Leadership Initiative (YALI). Part of an effort started in 2013, YALI supports and develops young African leaders and strengthens partnerships between the United States and Africa.

The fellows are all established entrepreneurs in Africa, with businesses ranging from developing skin care products to making peanut butter to developing eco-friendly fuels. The Farley classes exposed them to all aspects of the entrepreneurial process, teaching them how to think through challenges, manage finances, market their products, secure funding, and nurture partner relationships. At the end of the visit, six of the YALI fellows at Northwestern received federal grants—more than at any other school participating in the program.

SOCIETY OF WOMEN ENGINEERS WINS REGIONAL AWARD

Northwestern's chapter of the Society of Women Engineers (SWE) received the 2015–16 Best Collegiate Section Award for the Chicago regional section. The award honors the university chapter that best exemplifies SWE's goals: professional excellence, globalization, and advocacy. SWE's Chicago region stretches from northern Illinois to northern Indiana and includes nine institutions.

SWE members build networks with other female engineers and scientists to develop skills in leadership, problem-solving, and interpersonal relationships. Annual events, such as Career Day for Girls, aim to spark young girls' interest in science and engineering.

"We are thrilled to receive this award. Our chapter works hard to represent SWE's values and mission."

ELLEN WORSDALL
ASSISTANT DEAN OF UNDERGRADUATE ENGINEERING

140

Percent by which underrepresented minority PhD enrollment has increased at Northwestern Engineering over the past 10 years.

EXPERTS DISCUSS THE FUTURE OF INFRASTRUCTURE

A new Northwestern-led study explored how future trends and opportunities will influence US transportation infrastructure by the year 2050. The comprehensive study was unveiled in May at "Mobility 2050: A Vision for Transportation Infrastructure and How We Can Get There," a symposium that featured scholars, policymakers, and industry leaders. Victor Mendez, deputy secretary of the US Department of Transportation, delivered the keynote speech.

STUDENTS CELEBRATE COMMENCEMENT

The McCormick School of Engineering celebrated the graduation of its undergraduate, master's, and PhD program students on June 17 and 18 as part of the University's 158th commencement.

Keynote speaker for the undergraduate ceremony Chelsea Stoner ('96), general partner at the global technology-focused investment firm Battery Ventures, urged graduates to forge their own paths during their careers. "Be different, and be proud of it," she said. "True innovation and change doesn't happen if we all follow the crowd. Being different is what creates greatness. It's true in science, investing, and life in general. If everyone followed the herd, we'd never leap forward."

ENGINEERING THE ART OF ALLOWING

This past spring, the Office of Personal Development taught engineers "the art of allowing"—as opposed to controlling or dismissing—through improvisation techniques. PRDV 397: Engineering Improv helps students develop sensory awareness, attention and focus, collaboration, trust and support, and storytelling skills. Improv's team-building exercises also train students to work in teams in classes and later in their professional careers.

"TRUE INNOVATION AND CHANGE DOESN'T HAPPEN IF WE ALL FOLLOW THE CROWD. BEING DIFFERENT IS WHAT CREATES GREATNESS. IT'S TRUE IN SCIENCE, INVESTING, AND LIFE IN GENERAL. IF EVERYONE FOLLOWED THE HERD, WE'D NEVER LEAP FORWARD."

CHELSEA STONER '96

20

Years ago that professors Michael Peshkin and J. Edward Colgate invented Cobots, collaborative robots for manufacturing.

DESIGN FOR AMERICA PROJECT PROMOTES CYCLING SAFETY

Four Evanston intersections now sport informational signs that promote bikers' use of hand signals and educate all road users on the signals' meanings. The signs were conceived two years ago by a Design for America team aiming to use human-centered design to improve cycling safety. After the DFA team disbanded, senior Charlie Tokowitz completed the signs and introduced them to Evanston city officials.

MOTOROLA EXECUTIVE JIM WICKS JOINS NORTHWESTERN ENGINEERING

Jim Wicks, the Motorola executive responsible for the design of many of the top mobile products of the last decade, joined Northwestern Engineering in July. Wicks, who served as senior vice president of consumer experience design at Motorola, is now a full-time faculty member of the Segal Design Institute. He brings his decades of user-centered design experience to the Institute's undergraduate and graduate programs. He will teach design courses and serve as a mentor for student design teams.

LAB NOTES

NORTHWESTERN EXPERIMENTS HEAD TO SPACE

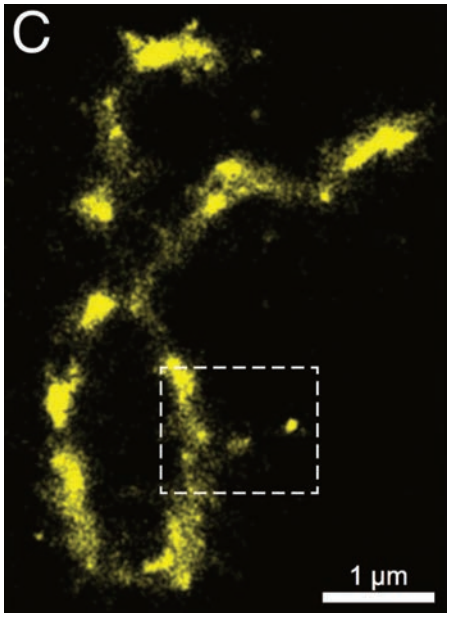
Professors David Dunand and Peter Voorhees's research projects are among 16 selected to be conducted aboard the International Space Station. The projects are funded by NASA's MaterialsLab, a program that supports experiments to investigate physical phenomena in the absence of gravity.

Dunand and Voorhees co-advise a project that creates foams made of titanium oxide and other ceramics through freeze casting, a process that benefits from zero gravity because the resulting structures are more regular than those created in the laboratory.

Voorhees's second funded experiment will examine fragmentation during the solidification of a metal. Performing the experiments in reduced gravity prevents fragments from settling, which enables measurement of the location and rate at which these fragments form.

"THIS IS EXCITING NEWS FOR NORTHWESTERN ENGINEERING. ONLY SIXTEEN PROJECTS WERE SELECTED NATIONWIDE FROM A VERY LARGE POOL, AND WE RECEIVED TWO OF THEM."

DAVID DUNAND
PROFESSOR OF MATERIALS SCIENCE AND ENGINEERING

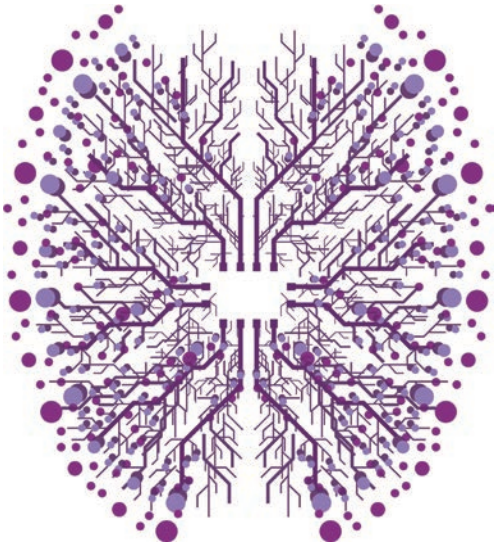


RESEARCHERS DISCOVER THAT DNA FLUORESCES NATURALLY

For decades, textbooks have taught that macromolecules within living cells do not fluoresce on their own. Technology instead relies on special fluorescent dyes to enhance contrast when macromolecules are imaged.

Now, Professors Vadim Backman, Hao Zhang, and Cheng Sun have discovered that macromolecule structures in living cells do naturally fluoresce. This finding could open the next frontier of biological discovery; pave a new way for label-free, super-resolution nanoscopic imaging; and expand the understanding of biological processes.

Why hasn't someone spotted the fluorescence before? The molecules were in the "dark state," a condition in which they do not absorb or emit light. The team discovered that when illuminated with visible light, the molecules get excited and light up well enough to be imaged without fluorescent stains.



MAKING COMPUTERS REASON AND LEARN BY ANALOGY

Professor Ken Forbus is closing the gap between humans and machines. Using cognitive science theories, Forbus and his collaborators have developed a model that could give computers the ability to reason more like humans and even make moral decisions. Called the structure-mapping engine (SME), the new model is capable of analogical problem solving, including capturing the way humans spontaneously use analogies to solve moral dilemmas.

Underlying the model is Northwestern psychologist Dedre Gentner's structure-mapping theory of analogy and similarity, which has been used to explain and predict many psychological phenomena. Structure-mapping argues that analogy and similarity involve comparisons among relational representations, which connect entities and ideas such as "the clock is above the door."

Analogies can be complex or simple. Previous models, including earlier versions of SME, have not been able to scale to the size of representations that people tend to use. Forbus's new version of SME can handle the size and complexity of relational representations needed for visual reasoning, cracking textbook problems, and solving moral dilemmas.

"SME IS ALREADY BEING USED IN EDUCATIONAL SOFTWARE, PROVIDING FEEDBACK TO STUDENTS BY COMPARING THEIR WORK WITH A TEACHER'S SOLUTION. BUT THERE IS A VAST UNTAPPED POTENTIAL FOR BUILDING SOFTWARE TUTORS THAT USE ANALOGY TO HELP STUDENTS LEARN."

KEN FORBUS WALTER P. MURPHY PROFESSOR OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Nanoscientists Develop the 'Ultimate Discovery Tool'

A Northwestern team is developing a tool to test millions and perhaps even billions or more different nanoparticles rapidly at one time with the goal of zeroing in on the best particle for a specific use.

Using a technique that deposits materials on a surface, Professors Chad Mirkin, Vinayak Dravid, Mark Hersam, and their teams figured out how to make libraries of nanoparticles in a very controlled way. These nanoparticle libraries are much like a gene chip where thousands of different spots of DNA are used to identify the presence of a disease or toxin. Thousands of reactions can be done simultaneously, delivering results in just a few hours. Similarly, the libraries will enable scientists to make and rapidly screen millions to billions of nanoparticles of different compositions and sizes for desirable physical and chemical properties.

20%

How much whisker removal decreased rats' chance of locating airflow sources, according to research by Professor Mitra Hartmann.

MASANET USES SABBATICAL FOR CLIMATE

Professor Eric Masanet is spending his sabbatical in Paris leading the Energy Demand Technology Unit of the International Energy Agency (IEA). Masanet develops mathematical models that quantify opportunities for reducing society's energy and resource use over different scales of time and space. Manufacturers, consumers, and policymakers use such models to identify technological, behavioral, and policy pathways toward more sustainable products and processes.

"Having sound data on how transitions to more sustainable energy systems can meet multiple societal goals—and at what cost—is imperative for accelerating policy action. This is where modeling can make a real difference," Masanet says.

Rat Whiskers Shed Light on How Neurons Communicate

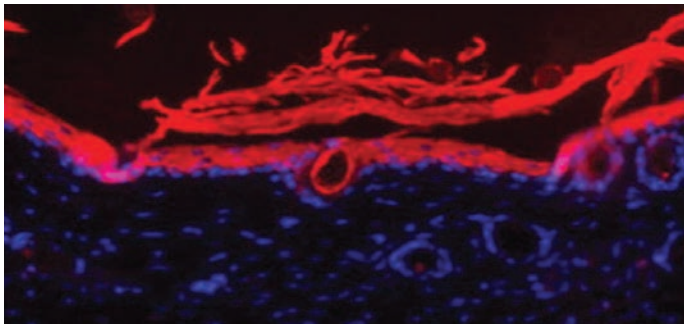
Professor Mitra Hartmann and her team discovered that whisker sensory neurons encode information about the forces and torques at the whisker's base—a finding that could resolve fundamental questions about how touch is represented and processed by neurons in both the rat and the human brain.

The study's goal was to resolve whether touch-sensitive neurons in the whisker system encode kinematic or mechanical information, a distinction that has historically posed a major challenge. When a whisker brushes against an object, it moves in a particular direction, by a particular amount, and at a particular speed. Together, these features are known as kinematic properties. Mechanical properties, by contrast, are related to the contact forces and torques at the whisker base.

Hartmann's team developed a novel whisker stimulation paradigm to decouple kinematic and mechanical variables. They found that the electrical activity of whisker-touch neurons was more accurately predicted by mechanics rather than kinematics.

"SPECIALIZED CELLS CONVERT TOUCH INFORMATION FROM THE WHISKERS INTO ELECTRICAL SIGNALS THAT THE BRAIN CAN INTERPRET."

MITRA HARTMANN PROFESSOR OF BIOMEDICAL AND MECHANICAL ENGINEERING



REGENERATIVE BANDAGE HEALS DIABETIC WOUNDS FASTER

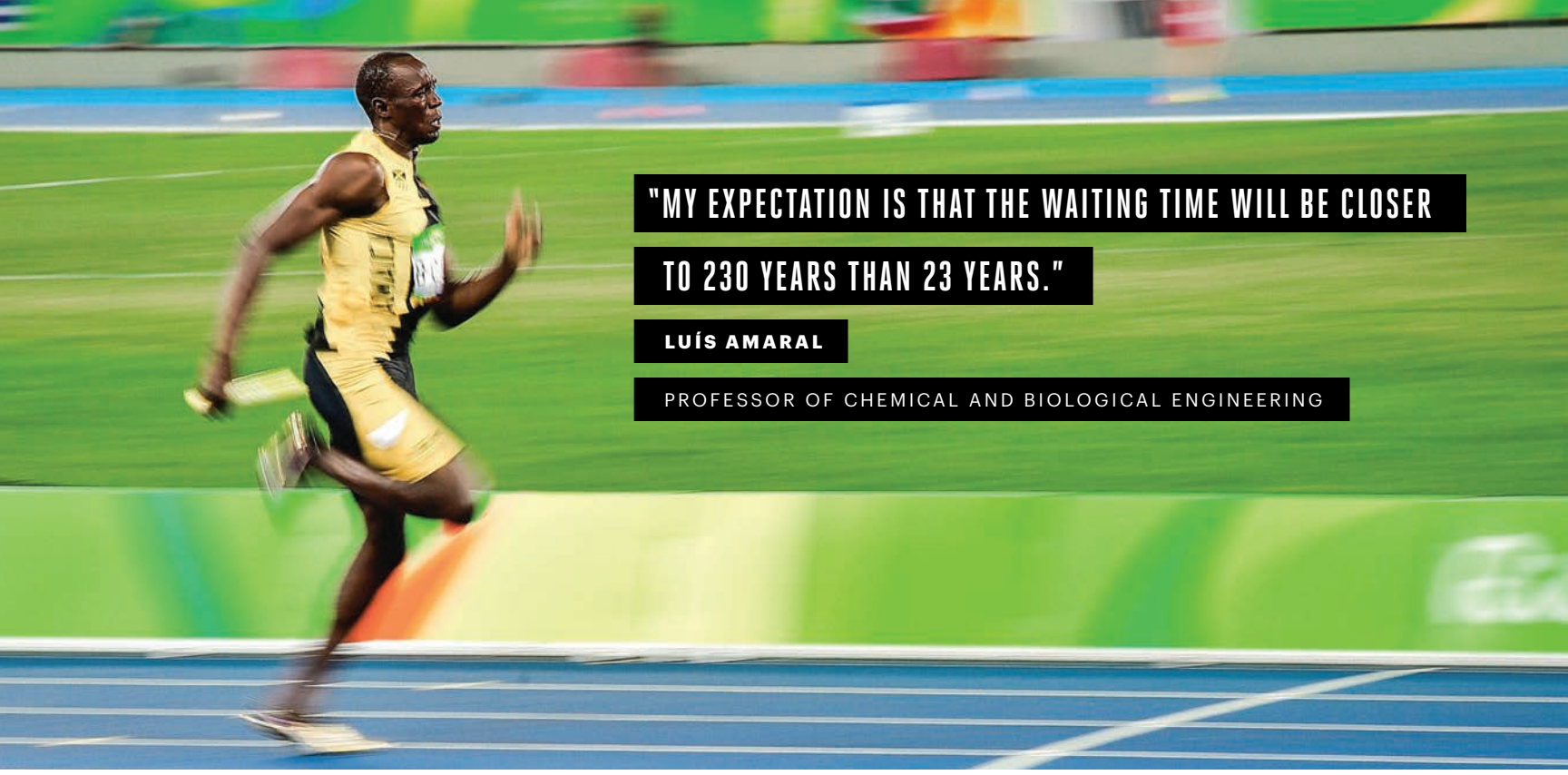
Professor Guillermo Ameer developed a new treatment for diabetic foot ulcers. Called a "regenerative bandage," the novel material heals diabetic wounds four times faster than a standard bandage and has the added benefit of promoting healing without side effects. The bandage releases a protein that hastens the body's ability to repair itself by recruiting stem cells to the wound and creating new blood vessels to increase blood circulation.

REINVENTING THE WHEEL: NORTHWESTERN RESEARCHERS DEVELOP RECYCLABLE RUBBER

The recyclability of a non-paper material—heated at high temperatures and recast for reuse—depends largely on how its polymers are linked. Polymers that are recycled typically are made of linear chains, which can be heated to high temperatures, remolded in their melted state, and effectively reformed when cooled. When rubber—which is made of permanently cross-linked chains—is heated, it strengthens and cannot be remolded or reheated into a usable product. Professor John Torkelson discovered a way to recycle rubber by separating the cross-links in rubber at high temperatures, making it possible for them to reform and retain their properties in a cooled state.

METHOD STABILIZES, ENHANCES PHOSPHORENE

Two years ago, Professor Mark Hersam discovered a way to stabilize phosphorene, a semiconductor that degrades in open air but shows great promise for electronics. By encapsulating it in aluminum oxide, he was able to stabilize phosphorene's reactivity. The problem was that the phosphorene was buried underneath the coating. By using organic chemistry to covalently react a single-molecule-thick layer onto phosphorene, Hersam and Professors Tobin Marks and George Schatz passivated the material while leaving access to the material's surface.



"MY EXPECTATION IS THAT THE WAITING TIME WILL BE CLOSER TO 230 YEARS THAN 23 YEARS."

LUÍS AMARAL

PROFESSOR OF CHEMICAL AND BIOLOGICAL ENGINEERING

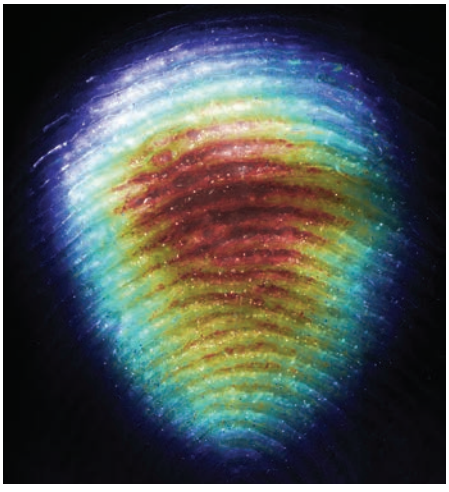
How Long Will It Take to Break Usain Bolt's Dash Record?

When Jamaican sprinter Usain Bolt won his third gold medal in the 100-meter dash at the 2016 Olympics, his focus was likely on performing his best—not on the statistical odds of breaking his own record.

But that's exactly what Professor Luís Amaral was thinking about. After running some calculations, Amaral found that it could take up to 230 years before Bolt's record is broken.

To reach this finding, Amaral needed to know how many capable sprinters there will be at any time and how many relevant races they will run each year. He assumed that, at any time in the present and in the future, there will be a cohort of about 10 sprinters who each could regularly run the 100-meter dash in less than 10 seconds. He also assumed that each of those sprinters can run the 10 officially timed, competitive races typically held every year. Thus, on average, there will be 100 races per year, and each race will have a probability of 0.00003 of a runner achieving a trial time of, at most, 9.57 seconds.

Amaral then calculated how many races would have to occur for the probability that the record will be broken to become greater than the probability that it will not be broken. That would happen after about 23,000 races. Given his estimate that 100 relevant races will be run each year, we may have to wait more than 230 years for the next record-breaking sprint. However, if the number of sprinters who can regularly run the 100-meter dash in less than 10 seconds increases over time, we may see that sooner.



Michaël Wiertlewski/CNRS

MYSTERY SOLVED: THE CASE OF THE SLIPPING FINGER

Haptics researchers have long known that applying ultrasonic vibrations to a flat, featureless glass plate makes it feel slippery. They also have long debated why. Professor J. Edward Colgate and his team have finally put the mystery to rest with the discovery that the vibrations reduce friction by causing the fingertip to bounce on pockets of trapped air.

This discovery will help researchers use vibrations to push a finger across a screen. This effect could, for example, help align the fingers over a keyboard, which could be potentially useful for people with vision impairment or in situations where they cannot use their eyes, such as when driving.

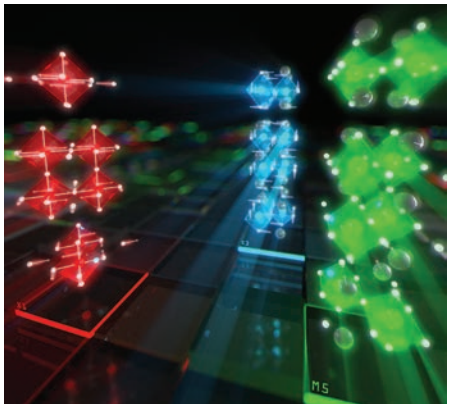
3

Number of invited Northwestern papers (out of 10) featured in the *PNAS* Novel Materials Special Feature issue.

FERROELECTRIC MATERIALS REACT UNEXPECTEDLY TO STRAIN

Until recently, researchers thought they had the behaviors of ferroelectric materials mostly figured out. "The conventional wisdom is that almost any material under mechanical stress will become ferroelectric or exhibit an electrical polarization," says Professor James Rondinelli. "If you apply similar stresses to a compound that's already ferroelectric, its polarization increases."

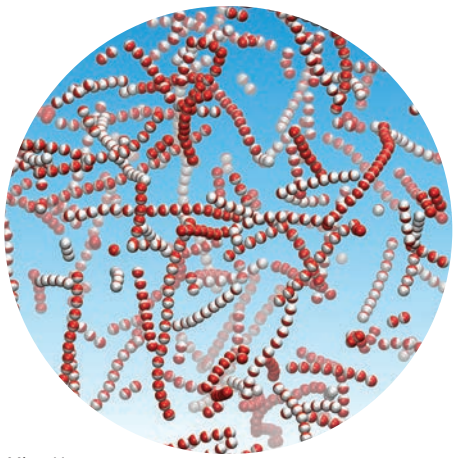
Rondinelli, however, has made a theoretical discovery that flips this accepted fact on its head. He found that when a class of ferroelectric oxides called layered perovskites are stretched or compressed, the polarization does not increase as expected. It goes away completely. Rondinelli made the discovery using theoretical materials tools and quantum mechanical simulations and is working with collaborators to validate the finding in the laboratory.



Justin Muir

"BASED ON EVERYTHING WE HAVE KNOWN FOR THE PAST TWO DECADES, THIS IS COMPLETELY UNEXPECTED."

JAMES RONDINELLI ASSISTANT PROFESSOR OF MATERIALS SCIENCE AND ENGINEERING



Ming Han

RECONFIGURING ACTIVE PARTICLES INTO DYNAMIC PATTERNS

Professors Erik Luijten of Northwestern Engineering and Steve Granick of Korea's Institute for Basic Science (IBS) have found a way to mimic dynamic behaviors in active materials on the microscale. By applying an electrostatic imbalance to Janus colloids, the researchers could control interactions among microscopic spheres—causing them to self-propel into swarms, chains, and clusters. Such active particles have the potential to open a new class of technologies with applications in medicine, chemistry, and engineering, as well as to advance scientists' fundamental understanding of collective, dynamic behavior in systems.

$5,646

Amount raised by Northwestern students on Experiment.com to fund their coral bleaching research.

LIGHT-POWERED 3-D PRINTER CREATES TERAHERTZ LENS

Professor Cheng Sun has used metamaterials and 3-D printing to develop a novel lens that works with terahertz frequencies, offering better imaging capabilities than common lenses. Sun's lens employs a gradient index, a refractive index that changes over space to create flawless images without requiring additional corrective components.

The lens could make terahertz imaging, which is useful for security purposes, cheaper, of higher resolution, and more available. Terahertz scanners can detect concealed weapons, biological weapons, and plastic explosives. Unlike X-rays, terahertz radiation is completely harmless to humans.

TWEETCAST PREDICTS YOUR VOTE

Whether you realize it or not, what you tweet says a lot about your politics. Developed by computer science professor Larry Birnbaum and his students, TweetCast could predict if a Twitter user would vote for Donald Trump or Hillary Clinton in the 2016 US presidential election. With an accuracy of 80 percent, the program uses an algorithm to examine words, hashtags, and mentioned websites to uncover which are most predictive of voting preference. Tweeting the words "lying," "liberal," and "money," for example, indicated a vote for Trump. Using the words "single," "rights," and "y'all," on the other hand, predicted a vote for Clinton.

Peter Voorhees

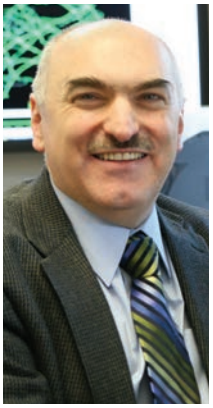
Monica Olvera de la Cruz

Elizabeth Gerber

Julius Lucks

Jian Cao

David Gatchell

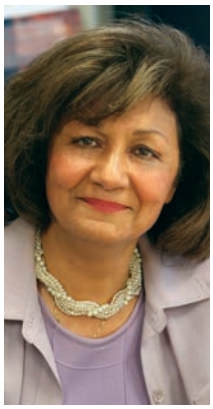


Hani Mahmassani

Zdeněk Bažant

Samuel Stupp

Madhav Mani



Manijeh Razeghi

Faculty Awards

Peter Voorhees Elected to American Academy of Arts and Sciences
Voorhees is among 213 members elected into the prestigious honorary society's 236th class.

Julius Lucks Receives ACS Young Investigator Award
The American Chemical Society Synthetic Biology Young Investigator Award recognized Lucks for his early contributions to the field.

Hani Mahmassani Named to 2016 Class of National Associates by National Research Council
Mahmassani, director of the Northwestern University Transportation Center, was recognized for his work as a member of the Transportation Research Board.

Madhav Mani Named Simons Investigator
Given by the Simons Foundation to outstanding junior faculty, the award will provide long-term funding for Mani's work in mathematical modeling of living systems.

Monica Olvera de la Cruz Receives APS Polymer Physics Prize
She was selected for her "outstanding contributions to the theoretical understanding of polymers and the effects of electrostatic interactions on their structure and properties."

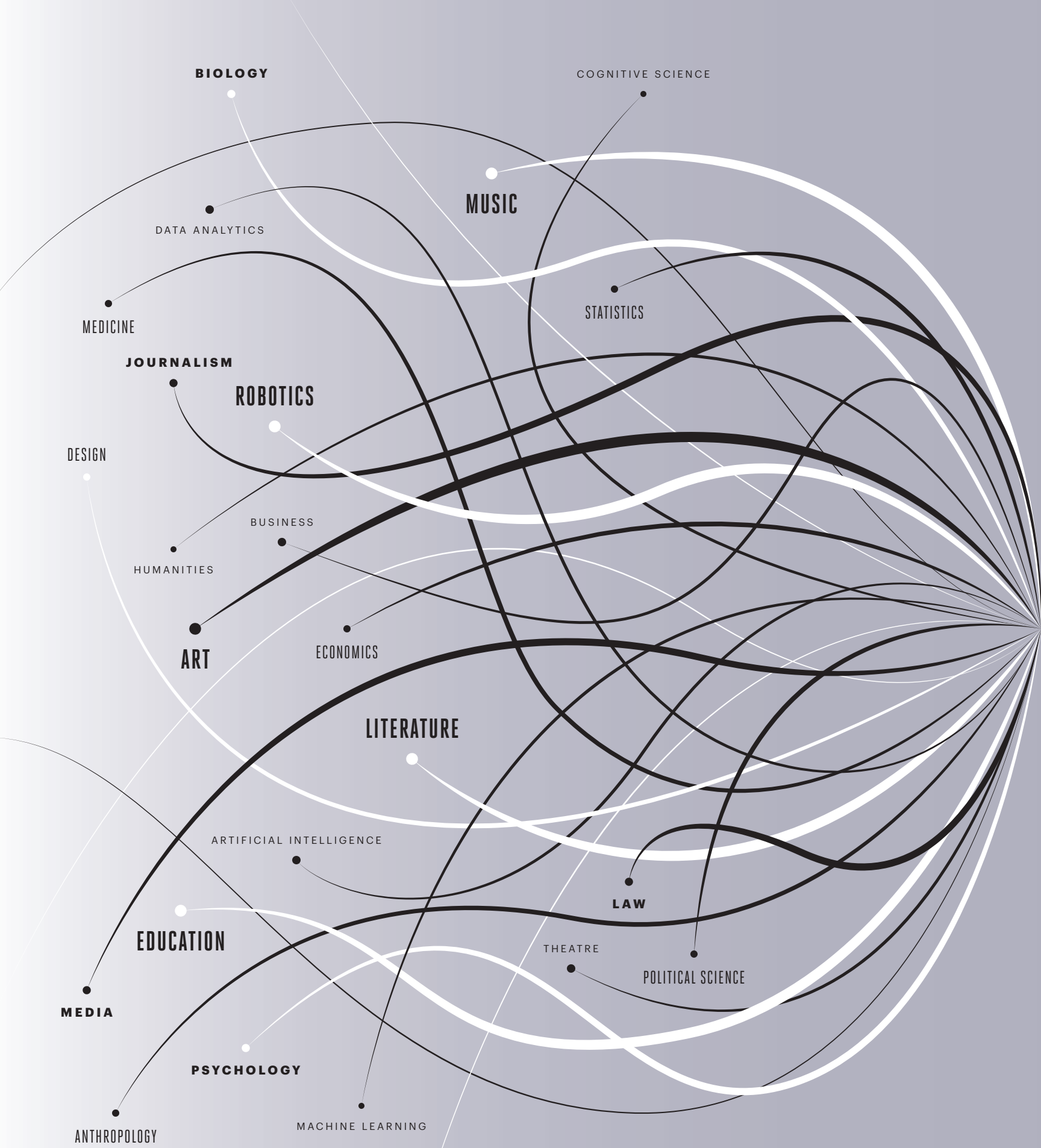
Jian Cao Receives SME's Taylor Medal
The first woman to receive the prestigious research award from SME (previously known as the Society of Manufacturing Engineers), Cao was honored for her pioneering and innovative research on manufacturing.

Top Honor for Zdeněk Bažant
Bažant received the Austrian Cross of Honor for Science and Art, First Class, from Austria's president, Heinz Fischer.

Two Honored with 2016 University Teaching Awards
Elizabeth Gerber and David Gatchell were honored for excellence, innovation, and influence in undergraduate teaching at Northwestern.

Samuel Stupp Receives Prestigious Chemistry Award
Stupp was honored with the Soft Matter and Biophysical Chemistry Award by the UK's Royal Society of Chemistry.

Manijeh Razeghi Receives Jan Czochralski Gold Medal
The award, given by the European Materials Research Society, recognizes her life achievements in the field of advanced materials science.


BIOLOGY
COGNITIVE SCIENCE
MUSIC
DATA ANALYTICS
STATISTICS
MEDICINE
JOURNALISM
ROBOTICS
DESIGN
BUSINESS
HUMANITIES
ART
ECONOMICS
LITERATURE
ARTIFICIAL INTELLIGENCE
LAW
EDUCATION
THEATRE
POLITICAL SCIENCE
MEDIA
PSYCHOLOGY
ANTHROPOLOGY
MACHINE LEARNING

THE EXPONENTIAL POWER OF COMPUTER SCIENCE

Doubling down on its commitment to computer science (CS), Northwestern aims to energize research, education, and economic opportunity.

We live in a world where nearly everyone everywhere has a computer in hand or tucked in a purse or pocket all the time. We talk to our computers, ask them for directions, and let them connect us to people next door or on the other side of the world. On a greater level, computers can drive our cars, help diagnose our diseases, and enable us to explore distant planets.

And this is just the beginning.

"THE SYNERGY BETWEEN COMPUTER SCIENCE AND CS+X IS EXCITING. WE HAVE THE OPPORTUNITY NOT ONLY TO REVOLUTIONIZE COMPUTER SCIENCE AT NORTHWESTERN, BUT ALSO TO REVOLUTIONIZE NORTHWESTERN WITH COMPUTER SCIENCE. WE'RE GOING TO INVENT NEW KINDS OF COMPUTER SCIENCE THROUGH CONNECTIONS WITH OTHER DISCIPLINES." **LARRY BIRNBAUM** PROFESSOR OF COMPUTER SCIENCE

As much as computers have already edged their way into so many of our daily activities, they are now poised to saturate our world and our lives in previously unimagined ways. Computers and computational thinking have already changed and amplified how researchers—in virtually every discipline—think about and use the constantly growing stockpiles of valuable, untapped data. Within the field of computer science itself, emerging specialties such as artificial intelligence, machine learning, robotics, and data analytics have the potential to transform nearly every field of endeavor.

"The power of computer science lies in augmenting our thinking and in its ability to accelerate research exponentially in other areas," says Julio M. Ottino, dean of Northwestern's McCormick School of Engineering. "Even areas as diverse as art, economics, medicine, and political science can benefit from integrating computational thinking into their research and education. The possibilities are endless."

Not surprisingly, Northwestern has experienced an unprecedented spike in student demand for CS courses and identified enormous opportunities for advanced CS research across multiple disciplines. To address these needs and opportunities, the University will add 20 full-time computer science faculty members, half in core computer science areas and the other half as CS+X appointments, which signifies a collaboration between computer science and another discipline. This investment will enable researchers to explore new pathways while empowering students with the essential knowledge of CS they need to do great things in the world.

"We have always recognized that computers are a tool to serve us and make our lives easier," says Kristian J. Hammond, professor of computer science. "But there are still massive areas where we have yet to discover just how much our lives can be enriched by computation."

UNPRECEDENTED DEMAND

In the past five years, student demand for computer science at Northwestern has soared, the number of computer science majors has tripled, and computer science courses have increased enormously in popularity among non-CS majors.

For new college graduates, basic computer science skills have become a prerequisite for many of the best jobs in the career marketplace, but Larry Birnbaum, professor of computer science, thinks that the exploding demand is about more than students wanting to improve their chances of landing a great job.

"Students see computer science as an area where they can really make a tremendous difference in the world and maybe do it quickly," Birnbaum says. "That's because the time and distance from the original conception of an idea to its ubiquitous acceptance and almost universal presence in the world is so much faster in computer science than in any other field."

Birnbaum believes that Northwestern's expanded commitment will enable faculty not just to introduce more students to computer science, but also to introduce computer science majors to new themes within the field. A student might be interested initially in programming, for example, but through new classes, uncover interests in artificial intelligence, data science, and complex systems.

"We're planning cross-cutting themes that will pull in a lot of people from diverse areas within computer science," Birnbaum says. "To pinpoint those themes, we're looking to the future of computer science and what areas will make that future happen faster."

BROADEST IMPACT

CS+X—computer science plus another discipline—marks the spot where many of the futuristic themes that Birnbaum references lie and where their impact can be greatest. The fundamental concept is not new at Northwestern: collaboration has a long history at the University. Several of the University's computer science professors hold joint appointments in fields as diverse as music, journalism, and education; and many of the newly funded faculty positions will focus on where different disciplines intersect.

In the CS+X faculty search, Hammond will look for researchers whose work can simultaneously affect several disparate fields. Computer science plus decision making, for example, could affect public policy, economics, sociology, and more. "We are looking for themes of impact—places where computer science can genuinely change not just one, but many fields," Hammond says. "We will identify the areas where we can foresee having the most outrageous impact and become leaders in those areas."

Birnbaum and Hammond should know: they are early CS+X pioneers. The duo founded Narrative Science, a company that uses artificial intelligence to extract the most important information from a data source and turn it into a narrative expressed in natural language. The underlying program resulted from a collaboration among the two professors, their students, and students from the Medill School of Journalism, Media, Integrated Marketing Communications. *The New York Times*, *Wired*, and *Business Insider* have featured coverage of Narrative Science, and it received a 2011 Chicago Innovation Award.

"I was drawn to CS+X because of the notion of impact," Hammond notes. "When you're an engineer, you want to build things for people to use. It's not about what the computer can do. It's about how we can use computers to help us do things better, faster, and easier."

Birnbaum says, "The synergy between computer science and CS+X is exciting. We have the opportunity not only to revolutionize computer science at Northwestern, but also to revolutionize Northwestern with computer science. We're going to invent new kinds of computer science through connections with other disciplines."

Other Northwestern Engineering professors also have brought their CS+X research advances to market successfully. 4C, a data science company that helps agencies, brands, and television networks plan, measure, and execute advertising campaigns more effectively was founded by Alok Choudhary, the Henry and Isabel Dever Professor of Electrical Engineering and Computer Science. 4C's algorithm tracks trillions of data points that reflect the behaviors of more than one billion consumers worldwide, including within social networks. It counts among its customers 400 of the Fortune 1000 companies.

GROWING CHICAGO TECH HUB

The symbiosis among Stanford, the University of California-Berkeley, and Silicon Valley is undeniable. The universities helped build the tech industry; the tech industry helped grow the universities.

California doesn't hold a monopoly on symbiosis. With companies like Narrative Science and 4C entering the marketplace, Chicago's technology and entrepreneurship scene is thriving. Birnbaum and Hammond believe that Northwestern is now positioned to contribute to and accelerate growth in this already booming ecosystem.

"It's not an accident that Microsoft and Amazon are in Seattle and that the University of Washington has a great computer science department," Birnbaum says. "These entities feed on each other and grow."

Northwestern is already known for its entrepreneurial students. With its Chicago presence and plans to expand its world-class faculty, Northwestern will strengthen research, train more students, and contribute to intellectual, academic, and economic growth in the Midwest.

"We can now create a generation of computer scientists focused on becoming agents of positive change," Hammond says. "They won't just look at the machine for its own sake. They'll look at it for the sake of the community as well."

AMANDA MORRIS

THE X-FACTOR

By connecting computer science with other disciplines, Northwestern researchers have the opportunity to revolutionize computer science and to create entirely new fields of study. This is CS+X: computer science plus another discipline.

Here just a few examples of Northwestern Engineers who constantly challenge the boundaries of this new frontier.

CS+MUSIC

An accomplished jazz musician, **Bryan Pardo** uses computer science to develop easy-to-understand tools for audio production. His tools include SocialEQ, an equalizer that lets the user achieve a desired effect by listening to the sound and rating alternatives.

CS+ROBOTICS

Working with the Rehabilitation Institute of Chicago, **Brenna Argall** combines computer science with robotics to develop devices for individuals with physical disabilities. Her work includes an autonomous wheelchair that uses technology similar to that in driverless cars.

CS+EDUCATION

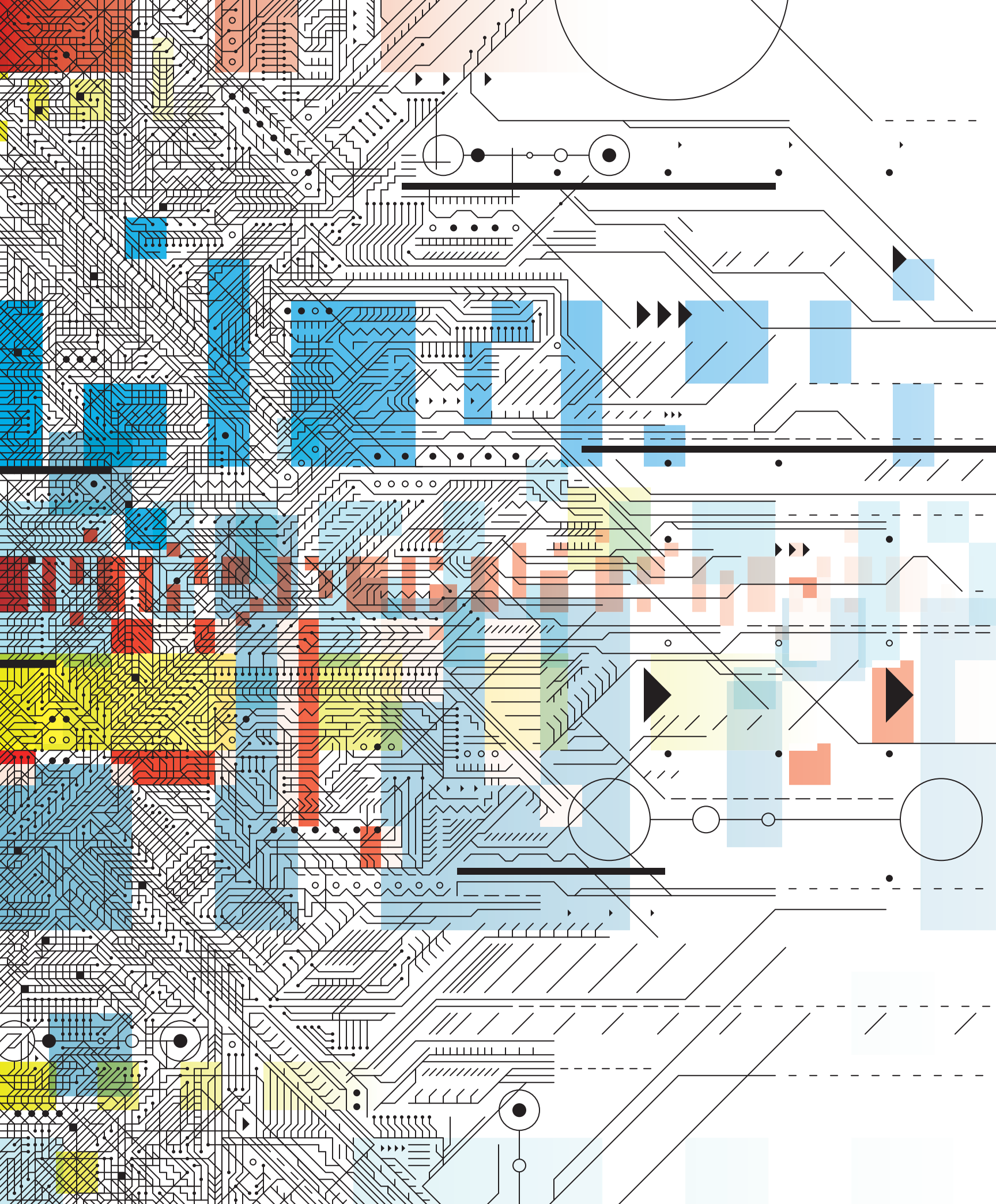
Michael Horn designs computer games that help school children learn difficult subject matter in engaging ways. Recently showcased at Chicago's Field Museum of Natural History, Horn's Build-a-Tree game helps players understand diagrams called phylogenetic trees that show the evolutionary history of organisms.

CS+ART

Oliver Cossairt uses computer imaging to uncover the hidden layers in works of art. A member of the Northwestern University/Art Institute of Chicago Center for Scientific Studies in the Arts, he helped reveal how Paul Gauguin created his Nativity print, which was found to be a layering of images created on paper by drawings, transfer of images, and two different inks.

CS+LITERATURE

Douglas Downey worked with Northwestern English and classics professor Martin Mueller to restore the millions of incomplete words in transcriptions of early English texts. Downey used machine-learning techniques to evaluate the contexts of the incomplete words and fill in the missing characters.



Optimizing A Faster, Smarter, Easier World

BIG DATA PLUS INCREASING COMPUTATIONAL POWER EMPOWER RESEARCHERS TO USE OPTIMIZATION ALGORITHMS TO BUILD A BETTER WORLD ON A GRANDER SCALE.

"We have trained algorithms with a lot of data, using massive computing resources, and something big has happened. We have created systems that are more intelligent than ever before."

JORGE NOCEDAL PROFESSOR OF INDUSTRIAL ENGINEERING AND MANAGEMENT SCIENCES

Searching for information online has become an integral part of everyday life. When you want to find something, a search engine rifles through 60 trillion pages and returns ranked results tailored precisely to your needs based on your location, language, previous searches, and more.

It all happens within a fraction of a second, and most people take it for granted—giving little or no thought to the complex programs that power these searches behind the scenes.

"People don't fully understand that a search engine is a technological marvel," says Jorge Nocedal, the David A. and Karen Richards Sachs Professor and Chair of Industrial Engineering and Management Sciences. "It's an incredible human accomplishment. You type a fairly complicated sentence and receive reliable answers within half a second. I never expected that we would be able to get so much information so easily and so reliably in such a short amount of time."

How does this happen? Much of the answer can be found in the science of optimization, and search engines are just one example of how this fast-growing discipline is making the world run faster, smarter, and easier. At Northwestern, engineers use optimization to improve everything from software to healthcare to renewable energy. With the University's new Center for Optimization and Statistical Learning (OSL) now open to support this work, optimization is finding its way into innovative collaborations across disciplines and schools.

FUELED BY DATA

The science of optimization has been around for a long time. Early engineers often used it to find the best designs for performance and aerodynamics. Nocedal, for example, remembers using optimization algorithms decades ago during his first job as an undergraduate at the National University of Mexico in Mexico City.

"I was probably 17 or 18 years old, and the astronomy department asked me to help design a new telescope with optimal optical properties," he says. "The question was how to use optimization algorithms to find the exact shape of a lens that would deliver the best possible quality images. I got hooked and have been optimizing ever since."

The science of optimization is a dynamic field. The unflagging influx of big data paired with the onset of powerful computing has revolutionized optimization in ways unimaginable even a decade ago.

"It's really the scale that has changed," says David Morton, professor of industrial engineering and management sciences and director of the new Center for Optimization and Statistical Learning. "The number of parameters or decision variables that you can optimize has increased to scales on the order of millions or tens of millions. It's not just big data and increased computational power, but new algorithms that can handle and exploit those things."

SQUEEZING UNCERTAINTY

The new Center, with its dual focus on optimization and statistical learning, has turned optimization science into a team sport. Optimization makes processes as perfect or as effective as possible; statistical learning ensures that optimization algorithms will always grow smarter and increasingly able to handle incoming data.

Statistical learning provides a framework for machine learning, a subfield of computer science that builds algorithms capable of learning from data and using that learning to make better predictions. To help accelerate machine learning, the Center connects researchers in engineering with experts in computer science.

"We have trained algorithms with a lot of data, using massive computing resources, and something big has happened," Nocedal says. "We have created systems that are more intelligent than ever before."

The ultimate goal is to develop better decision-making models that squeeze out as much uncertainty as possible. Uncertainty involves imperfect or unknown information. Optimization models attempt to compensate for this.

For example, Morton's latest work, a multi-institutional collaboration funded by the US Department of Energy, focuses on designing and building systems that generate solar power by using mirrors to concentrate large areas of sunlight into a small area.

"There is uncertainty in terms of solar radiance," he says. "What will happen when there's cloud cover? What if the mirrors fail? How does the system change as it degrades over time? You have to take uncertainty into account to find the optimal design under all those conditions."

Northwestern Engineering Puts Optimization to Work.

Northwestern researchers and innovators leverage optimization principles across wide-ranging endeavors in groundbreaking ways.

OPTIMIZING TEAMS

NOSHIR CONTRACTOR works to map, understand, and enable the most effective networks in a wide variety of contexts, including for teams traveling to Mars.

OPTIMIZING WI-FI

RANDALL BERRY helps develop distributed resource allocation techniques for wireless networks.

OPTIMIZING SEARCH

DOUGLAS DOWNEY develops techniques and prototypes that extend the state of the art for search engines.

OPTIMIZING SOFTWARE

ANDREAS WÄCHTER develops open-source, general purpose optimization software that can be used in many different fields across both academia and industry.

OPTIMIZING MUSIC

BRYAN PARDO turns complicated audio production software into easy-to-understand interfaces and terms.

OPTIMIZING THE GRID

ERMIN WEI works to help make the power grid more cost-effective and sustainable.

OPTIMIZING SHIPPING

DIEGO KLABJAN helps logistics companies plan the most efficient shipping routes.

OPTIMIZING THE MARATHON

KAREN SMILOWITZ works to make the Chicago Marathon safer and smoother.

OPTIMIZING ORGANS

SANJAY MEHROTRA developed a model to help optimize kidney distribution for organ donation.

ROBUST OPTIMIZATION

Sometimes uncertainty can mean the difference between life or death. Omid Nohadani, associate professor of industrial engineering and management sciences, uses algorithms to optimize radiation therapy. His work takes into account how cancer changes as a tumor shrinks or grows, or even how the tumor's position moves as a person undergoing therapy coughs or breathes. The radiation needs to be delivered at certain angles, which take these subtle changes into account.

"You want to use the best angles and radiation intensity to harm the tumor while sparing the healthy tissue," Nohadani says. "There are many variables you have to take into account to deliver the optimal dose."

To best meet this goal, Nohadani uses a strategy called robust optimization, a methodology that has developed rapidly over just the past 15 years. Very simply stated, the methodology uses algorithms that take risk and uncertainties into account and acknowledges that the most robust position is not always the best position. With radiation therapy, for example, a radiation dosage at the optimal intensity to shrink the tumor fastest might not be the best therapy for the patient's overall health. A lower radiation dose might take longer to shrink the tumor, but it might also minimize damage to the surrounding tissue when uncertainties arise.

"In healthcare, if you make a small mistake, it can make a big impact," Nohadani says. "You want to make the safer bet."

OPTIMIZING THE FUTURE

When Jorge Nocedal develops optimization algorithms, he keeps an eye on the future. In recent years, his work has focused on speech recognition systems. He imagines a world in which computers understand and immediately translate what people say into other languages, which would enable two people speaking different languages to converse meaningfully in real time.

Nocedal also envisions that the optimization algorithms for speech recognition could be applied to image recognition. To do this, Nocedal rejects the common, linear models that dominated the field for so long and instead uses non-linear models, which take into account increasing complexity and greater freedom.

"Non-linear algorithms used to scare people," he says, "but they are responsible for recent advances in speech and image recognition."

Nocedal describes the linear vs. non-linear concept using basic economics. Over time, for example, automobile prices have risen steadily a little each year in a linear fashion. Eventually there might be a sale. In a non-linear model, the industry might falter in some manner, causing prices to periodically drop.

"A lot of behavior does not follow a line," Nocedal says. "A lot of behavior follows curves. After all, the world is not a linear place."

AMANDA MORRIS

A RACE AGAINST TIME

DEVELOPING DIAGNOSTICS FOR THE DEVELOPING WORLD

Northwestern's Center for Innovation in Global Health Technologies tailors medical diagnostics to meet life-or-death challenges in the developing world.

For parents living in rural African villages, getting their newborns tested for HIV is not only a struggle, but also a race against time. For them and all parents of the 1.4 million babies born each year to HIV-infected mothers—who can pass the infection on during pregnancy, childbirth, or breastfeeding—getting reliable test results in a timely manner is literally a matter of life and death.

It's hard to believe that in the 21st century, children's lives hang in the balance because of a logistics issue. In rural Africa, however, the issue is alarmingly and devastatingly real.

There, central laboratory testing often adheres to a monthly schedule; drivers pick up blood samples from the surrounding area clinics just once per month. The samples travel sometimes two weeks before arriving at the laboratory. After testing, results return to the clinics on the same monthly schedule. If roads flood or conflicts break out, results take even longer—or never return at all.

"It can take several months of waiting," says Northwestern Engineering's Matthew R. Glucksberg. "Babies don't have the immune systems to wait that long. These tests were not designed for this type of environment or infrastructure." He adds that nearly 50 percent of test results never even make it back to the originating site.

A professor of biomedical engineering, Glucksberg leads Northwestern's Center for Innovation in Global Health Technologies (CIGHT), which is actively developing faster, cheaper, and more accessible diagnostics for infant HIV, HIV viral load, tuberculosis, and hepatitis C. The Center works closely with the Northwestern Global Health Foundation to commercialize these devices and move them into clinics.

Because traditional biotech companies have difficulty making devices for the developing world profitably, Northwestern faculty created the foundation as a new nonprofit model to commercialize technology for those who need it most.

Here are some examples of how the CIGHT team uses innovation tailored to developing countries to save lives.

Infant HIV Test

NEED

Cheap and fast HIV tests for adults already exist: they require only a drop of blood and 15 minutes to produce an accurate result. Unfortunately, these tests cannot be used for infants.

"These tests are wonderful because they are fast and cheap, but they don't do a good job of actually detecting the virus," explains Kara Palamountain, director of the Kellogg School of Management's Global Health Initiative and president of the Northwestern Global Health Foundation. That's because these tests measure antibodies, which newborns share with their mothers for the first 18 months of their lives. "If you use them on babies," says Palamountain, "you end up with a lot of false positives."

SOLUTION

The LYNX HIV p24 antigen test developed by Northwestern Engineering's David Kelso, clinical professor of biomedical engineering, detects the actual proteins from the virus in infant blood samples.

BENEFITS

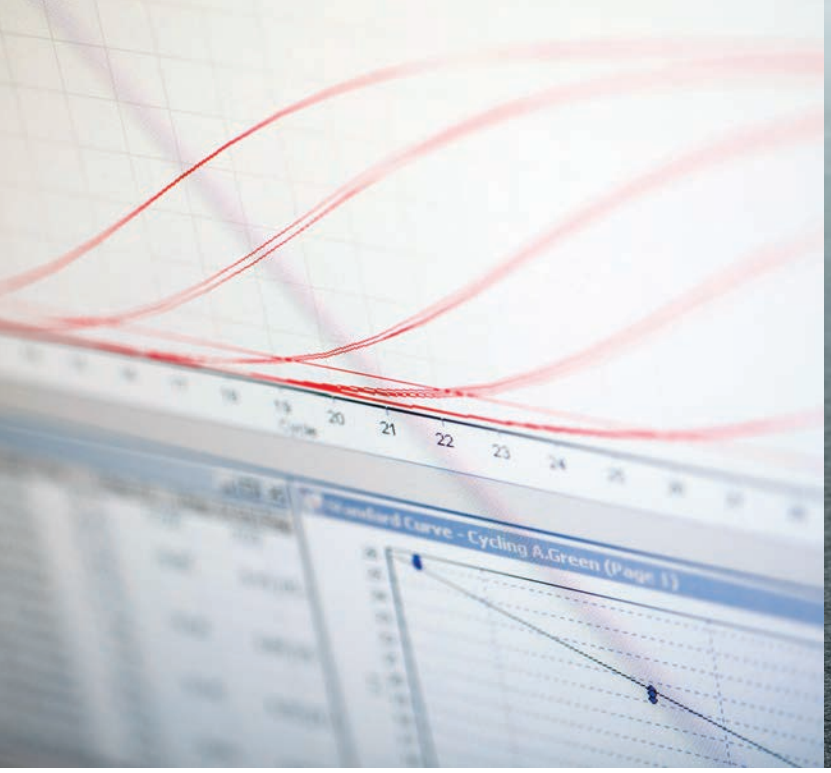
- Kelso's test delivers accurate results in under an hour, while the parents wait.
- The testing device, the size of a toaster, is powered with a rechargeable battery and fits into a backpack for easy transport to rural settings.
- The test needs only three drops of blood, easily collected from a baby's heel.
- Plasma is separated by a passive filter, eliminating the need for a costly centrifuge.
- Results can be read visually. One line on the paper test strip indicates a negative result, two lines a positive.
- Cost is $7 to $15 per test and $700 to $2,000 per testing device compared to other point-of-care instruments, which range from $25,000 to hundreds of thousands each.

NEXT

The Northwestern Global Health Foundation has agreed to manufacture and raise money to scale the device.

opposite top CIGHT's infant HIV test can produce reliable, accurate results with just three drops of blood taken from a baby's heel. A drop of blood is placed on a paper test strip (shown at top), which can detect the presence of the actual virus. One line on the test strip indicates a negative result; two lines indicate a positive result. From blood sample to results, the whole process takes less than an hour.

Photographs by Chris Strong



A computer read-out indicates a patient's HIV viral load.

CIGHT's proprietary sputum cup gives patients goal lines to help them produce more viable samples.

HIV Viral Load Test

NEED

Viral load refers to the amount of HIV in a blood sample—critical information for HIV patients. A high viral load means that their current dose of antiretroviral drugs—if they are taking them at all—is ineffective, and that the virus is healthy and replicating in the body. People with a high viral load are more likely to pass the virus along to partners and offspring.

To monitor HIV patients' health and the efficacy of treatment successfully, physicians must test viral load on a regular basis. In Africa, a physician shortage plagues the clinics, which are few and far between. Patients are often unable or unwilling to make distant round trips for testing and again for the results.

SOLUTION

The CIGHT team developed an HIV viral load test that delivers results within 60 minutes.

BENEFITS

- Test results can be available quickly while the patient waits.
- Daily throughput is 13 tests per eight-hour shift.

NEXT

Quidel Corporation has agreed to manufacturer the HIV viral load test for use on their Savanna Molecular Platform, which is in development and expected in the next 12 to 24 months.

Tuberculosis Testing

Few infected people know they have it, but about one-third of the world has latent tuberculosis. Most can live long, healthy lives without needing testing and treatment. If their immune systems struggle, however, tuberculosis can transform from latent to active.

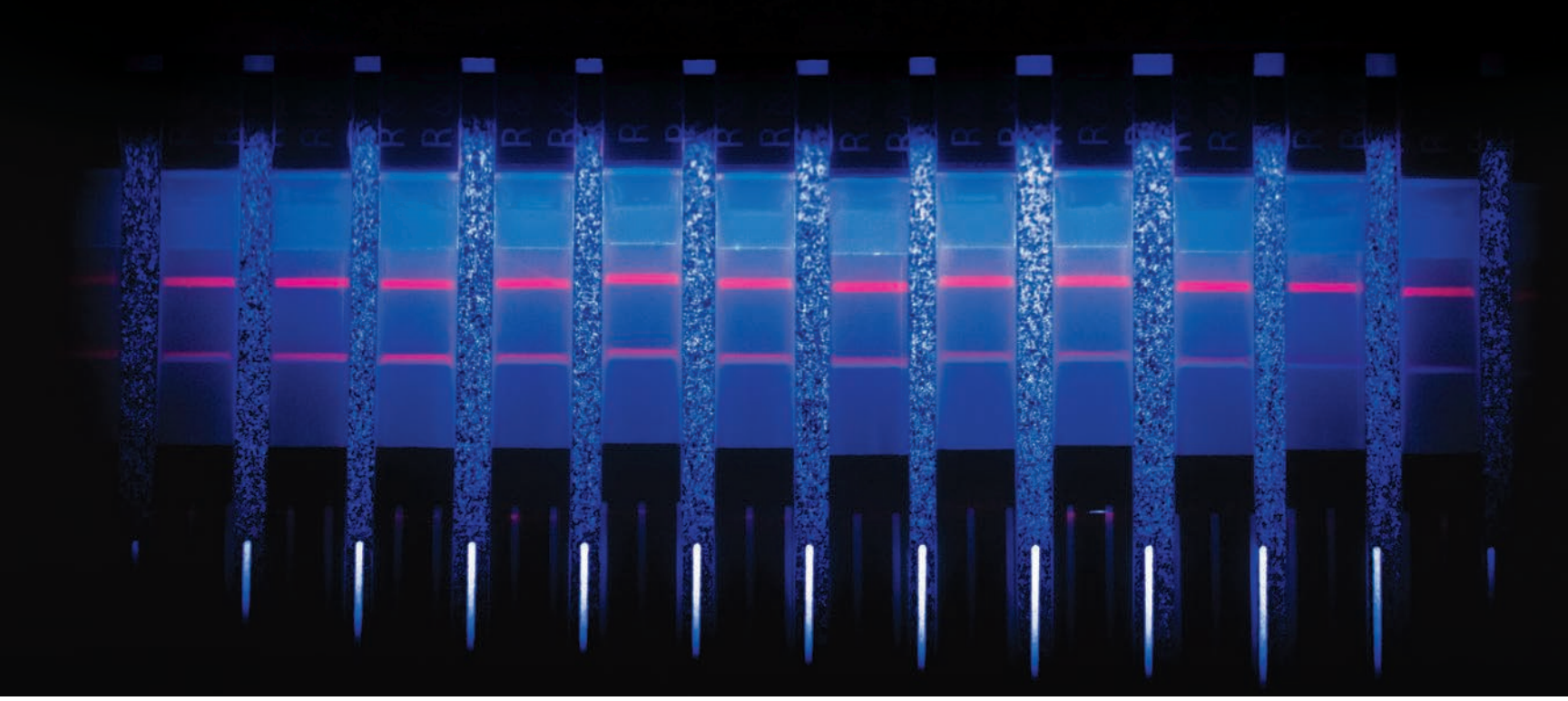
"Tuberculosis and HIV are very connected diseases," Palamountain says. "If a person is HIV positive and not doing well, the immune system can become depleted. That's when tuberculosis can switch to its active form, which is really dangerous."

NEED

Medical personnel find working with active tuberculosis samples very difficult. Instead of testing easy-to-access fluids, such as blood or urine, they can only detect active tuberculosis in a patient's sputum, a mixture of saliva and mucus coughed up from the lungs as an immune response to respiratory tract infections. After a patient produces a sample, also tricky, the sputum is liquefied, examined under a microscope, and grown in a petri dish, which can take months. Because active tuberculosis is very contagious, samples require careful handling to prevent contaminating the lab.

"You can imagine how dangerous this can be," Palamountain says. "South Africa is one of the few countries in Africa that cultures tuberculosis outside of a research setting. Most places won't even bother with it and rely instead on physicians' intuition, which can be pretty good, but there just aren't enough physicians to diagnose everyone."

Some physicians attempt to bypass the lengthy and dangerous culture process by diagnosing tuberculosis using lung X-rays.



Paper test strips glow with results from the hepatitis C test: two lines is positive; one line is negative.

If patients come in early enough, tuberculosis presents itself in a distinctive position: the lung's upper right lobe. If they fail to come in early, it's a different story.

"If tuberculosis has spread all over the lungs, physicians can't give a specific diagnosis," Glucksberg says. "It could be anything."

SOLUTION

More HIV patients die from tuberculosis than any other cause. Because they are among the most vulnerable, they can be tested for active tuberculosis at the same time as their HIV viral load testing, saving them multiple visits to different sites for different tests at different times. This offers patients a one-stop shop that not only expedites results, but also speeds the start of treatment.

BENEFITS

- While most active tuberculosis tests are 40 to 70 percent sensitive, preliminary results show that CIGHT's sensitivity is greater than 95 percent—meaning it diagnoses positive cases correctly 95 percent of the time.
- Results are delivered in one hour compared to the weeks or months required to grow and analyze a culture.
- Sputum samples are collected in a safe, proprietary cup to keep contamination risk low.

NEXT

CIGHT's tuberculosis test is on track to be the world's breakthrough method for diagnosing active tuberculosis and could be ported onto a molecular platform such as Savanna.

Hepatitis C Testing

Although medical science now has a cure for hepatitis C, many people don't even know they need it. "Hepatitis C is asymptomatic for a long time in most people, so they don't think about it," Glucksberg says. "If it's not detected and treated, patients can end up with cirrhosis of the liver or liver cancer."

NEED

Many people with hepatitis C have immune systems strong enough to fight off the disease. At up to $1,000 per pill for 85 pills, the cure for hepatitis C is an expensive course of treatment that few can afford. It doesn't make sense to put patients through this treatment if they can clear the illness on their own.

SOLUTION

CIGHT is pursuing both a molecular and core antigen approach for diagnosing chronic hepatitis C. A hepatitis C test could also be ported onto a molecular platform such as Savanna.

BENEFITS

- Identifies candidates for life-saving hepatitis C treatment and weeds out those that have cleared the hepatitis C virus on their own.
- Confirms that the hepatitis C treatment has worked.

NEXT

With initial funding from the National Institutes for Health and the nonprofit FIND, CIGHT continues to work with corporate and nonprofit collaborators to develop a low-cost hepatitis C test.

Written by Amanda Morris

STARTUPS GROW UP

SUCCESS STORIES FROM THE FRONT

GROUNDED IN WHOLE-BRAIN THINKING and applying the knowledge and skills they honed through interdisciplinary coursework, many Northwestern Engineering alumni-entrepreneurs have taken their student initiatives and innovations to new heights in the marketplace. Here's what *Northwestern Engineering* learned when we reached out to four of these alumni-founded startups.

POST GRADUATION, THESE NORTHWESTERN ENGINEERING ALUMNI AND THEIR STARTUPS CONTINUE TO MAKE A POSITIVE IMPACT IN HEALTH, EDUCATION, TECHNOLOGY, AND ADVERTISING.

ADAPTLY | FOUNDED: 2010

The Business Adaptly offers a platform to help advertisers purchase and optimize ad campaigns across all social networks.

The Alumni Nikhil Sethi (electrical engineering '10), co-founder and chief executive officer; Garrett Ullom (former Northwestern Engineering student), chief technology officer

The Start Sethi's vision for Adaptly took shape while he was a senior in NUvention: Web, a course offered by the Farley Center for Entrepreneurship and Innovation in which interdisciplinary student teams collaborate on developing and launching software-based companies.

Previously Co-founder Sethi was named to the 2012 *Forbes*' "30 Under 30" list as "an innovator to watch" after Adaptly—just two years old at the time—had raised $13 million in investor funding and included on its client list the likes of PepsiCo, Kraft, and Arby's.

The Latest Adaptly continues to scale its presence globally while growing its social media partnerships. In 2016, the company announced its status as a Snapchat Partner, which enabled the integration of Snap Ads into Adaptly's media buying campaigns. The company also released a case study documenting how its platform helped KFC reach 10 million consumers during the fast-food giant's 2015 "Pack More into Lunch" ad campaign.

LUNA LIGHTS | FOUNDED: 2014

The Business Luna Lights, an automated lighting system, reduces the risk of falling by guiding older and other at-risk individuals in their homes at night. Users sleep on a pressure-sensing pad that employs radio frequencies to trigger a lighting system when the user gets out of bed.

The Alumni Donovan Morrison (biomedical engineering '14), co-founder and chief executive officer; Matthew Wilcox (mechanical engineering '14), co-founder and chief technology officer; Wesley Youman (civil engineering '15), former chief operating officer

The Start In 2012, working through Design for America, the interdisciplinary student initiative founded at Northwestern and focused on how human-centered design can positively impact communities, the Luna Lights team members partnered with The Mather, an Evanston-based retirement community, to explore ways to reduce falls among older adults.

Previously Working with The Mather, Luna Lights wrapped an initial pilot program that tested the technology with the facility's residents in the spring of 2015.

The Latest Presbyterian Homes' Lake Forest Place received the first installation of Luna Lights in September 2016. With $225,000 in new funding recently raised from several investment groups, including Impact Engine, Breakpoint Ventures, and Chicago ArchAngels, the team plans to expand the capabilities of the analytics platform that drives the lighting system, as well as ramp up manufacturing efforts to bring Luna Lights to senior living communities across the United States.

SPROUTEL | FOUNDED: 2012

The Business Tapping into the power of storytelling and play, Sproutel creates toys, games, and experiences to help children learn about their health. The company's flagship product, Jerry the Bear, is an interactive stuffed animal that helps children manage type-1 diabetes.

The Alumni Hannah Chung (mechanical engineering '12), co-founder and chief creative officer; Aaron Horowitz (combined studies '12), co-founder and chief executive officer

The Start Jerry the Bear was the first Design for America project started by Chung in 2009. Horowitz joined the team in 2010 and together they built the first prototype.

Previously Co-founders Chung and Horowitz introduced President Barack Obama to Jerry the Bear as part of the 2015 White House Demo Day, an event recognizing startup companies founded by women and/or underrepresented minorities.

The Latest Sproutel recently received a utility patent on the core technology powering Jerry the Bear, which is now at work in 25 percent of pediatric endocrinologist offices across the country. The company is also making strides to secure corporate partnerships to strengthen connections between play and health among a broader audience, with plans to launch new products that will assist children suffering from cystic fibrosis and battling obesity.

SWIPESENSE | FOUNDED: 2012

The Business SwipeSense connects hospital operations to the Internet. The company's first application is a hand hygiene improvement tool that reduces the number of hospital-acquired infections and helps avoid costly penalties.

The Alumni Mert Iseri (combined studies '11), co-founder and chief executive officer; Yuri Malina (integrated science '11, Weinberg College of Arts and Sciences), co-founder and chief product officer

The Start NorthShore University HealthSystem's Evanston Hospital, a Design for America client, approached Iseri and Malina in 2009 to help improve hand-hygiene practices among doctors, nurses, and staff. After learning about the countless hours hospital personnel spent measuring hand hygiene, the duo designed a simple, sleek device that leverages technology to record hand sanitizer usage information and promotes good habits.

Previously Following the company's top-three finish in *The Wall Street Journal*'s "*WSJ* Startup of the Year" competition in 2013, Iseri and Malina were named to *Forbes*' 2015 class of "30 Under 30 Social Entrepreneurs."

The Latest SwipeSense received $4 million in new venture capital in July 2016, bringing its funding total to $16.9 million. The company continues to scale its product's national presence with notable results; one customer reported a 70 percent drop in hospital-acquired infections. SwipeSense has continued to expand its team to include nearly a dozen new engineers, technicians, and project managers. It was also named a finalist for the "Industry Disrupter Award" by the Illinois Technology Association's 17th Annual CityLIGHTS Awards.

above, left to right Luna Lights' sensor-based lighting system installs in minutes and automatically turns on after a user gets out of bed. Sproutel's Jerry the Bear helps children with type-1 diabetes learn positive habits like checking blood glucose levels and eating healthy foods. SwipeSense offers real-time data to monitor and analyze hand sanitizing compliance levels and encourage sustainable change.

Written by Alex Gerage

FLEXIBLE THINKING, EXPANSIVE IDEAS

JOHN ROGERS BENDS HISTORICALLY RIGID IDEAS ABOUT ELECTRONICS TO CREATE NEW MEDICAL MONITORING AND TREATMENT DEVICES THAT FLEX AND STRETCH WITH THE HUMAN BODY.

YOU SEE THEM NEARLY EVERYWHERE—CLINGING TO WRISTS, CLIPPED TO POCKETS, AND EVEN EMBEDDED IN MOST SMARTPHONES. AS OF 2014, ONE IN FIVE AMERICANS REPORTED OWNING A WEARABLE DEVICE TO MONITOR FITNESS, MANAGE SLEEP, OR TRACK THEIR HEART RATES. THE NUMBER OF USERS GROWS DAILY.

Now imagine what would happen if these devices went beyond just being wearable in the conventional sense—adhering directly to our skin, for example, or becoming seamlessly integrated into our bodies—with functionality that extended beyond simply monitoring fitness to providing clinical-grade health tracking and actually treating illnesses.

That is exactly what John Rogers imagines and what he's actually bringing to life. A renowned bioelectronics pioneer, Rogers develops novel bio-integrated electronic devices that have the potential to revolutionize materials science, engineering, and medicine.

"All wearable devices that exist today use the same engineering principles," Rogers says. "They all require a hard piece of electronics and a battery, fixed in a very clumsy way to the body with a strap or wristband, with the goal of tracking health and wellness. The measurement capabilities and the fidelity of those measurements are highly constrained, however, by the lack of stable, intimate interface to the body. As a result, these devices can provide information on 'steps' or 'activity level,' but they cannot yield clinically meaningful data."

BRINGING BIOELECTRONICS LEADERSHIP TO NORTHWESTERN

Rogers, who joined Northwestern this fall as the Louis Simpson and Kimberly Querrey Professor of Materials Science and Engineering, Biomedical Engineering and Neurological Surgery, has gained international recognition for developing bioelectronics—classes of soft, biocompatible electronic devices that can integrate seamlessly with the human body to provide a range of functions that can address challenges in clinical medicine and health.

For example, he has developed a suite of health monitoring devices that look and feel like temporary tattoos, which are radically different from conventional wearables that exploit the typical watch or wristband format. Such devices uniformly, softly adhere to the surface of the skin, collecting the person's vital signs and then wirelessly transmitting that data to a computer or smartphone equipped with the kind of technology used in mobile financial transactions.

"Our devices can make measurements that quantitatively match those of gold-standard hospital instruments," says Rogers, whose bendable, stretchable electronic devices also include implantable medical devices that can harvest energy from organs, wirelessly monitor biological processes, and automatically treat medical conditions, such as abnormal heart rhythms. "This is a key qualitative difference between what we're able to do by leveraging new ideas in materials science, mechanics, and manufacturing and what is possible with wearables as they exist today."

Rogers leads the new Center for Bio-Integrated Electronics, part of the Simpson Querrey Institute for BioNanotechnology housed in the new Louis A. Simpson and Kimberly K. Querrey Biomedical Research Center on Northwestern's Chicago campus. Although his primary appointment is in the McCormick School of Engineering, Rogers has an additional appointment in Northwestern's Feinberg School of Medicine.

"Invention requires expertise and creative thinking in many areas," says Rogers, who comes to Northwestern from the University of Illinois at Urbana–Champaign. "Joining a university that really fosters interdisciplinary work, and where there are close connections between the schools of engineering and medicine in support of an active hospital and rehabilitation enterprise, was very important for us at this stage of our work."

AN INTERDISCIPLINARY, "BELL-LABSIAN" VIEW

After earning a PhD at the Massachusetts Institute of Technology and serving as a postdoctoral fellow at Harvard University, Rogers joined Bell Laboratories as a technical staff member in its Condensed Matter Physics Research Department. He credits his seven years there for shaping his approach to research, which he describes as interdisciplinary, fundamental science with potential for broader consequences in engineering and technology beyond the lab.

"The Bell Labs style didn't involve an application-constrained approach to research, but rather one of research with an eye toward potential applications," Rogers says. "I have tried to adopt and morph that spirit for my lab. It's a 'Bell-Labsian' worldview, I guess."

Photograph by Chris Strong

"MOVING BEYOND RIGID, POINT-CONTACT ELECTRODES AS INTERFACES TO THE BODY, TO FULLY INTEGRATED, SOFT FORMS OF ELECTRONICS FOR DRASTICALLY INCREASED LEVELS OF FUNCTIONALITY—BLURRING THE BOUNDARIES BETWEEN BIOLOGY AND ELECTRONICS."

JOHN ROGERS
PROFESSOR OF MATERIALS SCIENCE AND ENGINEERING, BIOMEDICAL ENGINEERING AND NEUROLOGICAL SURGERY

That mindset led Rogers to his current work in health monitoring devices. Initially interested in novel electronic materials, Rogers hoped to make integrated circuits, traditionally made of rigid silicon, more flexible—for use perhaps in roll-up displays. It wasn't until a team of neurologists at the University of Pennsylvania suggested that these flexible electronic systems could be placed directly onto the brain and used for monitoring that he realized a compelling and much broader relevance for his work in human health.

"We had never thought about this," Rogers says. "It placed different requirements on the materials and mechanics of our devices, but we started to think about how to build soft electronics systems and about how they might offer new ways to interface technology with the human body."

ELECTRONICS, NOT ELECTRODES

Researchers and physicians have used electrodes for medical purposes for hundreds of years. An electrocardiogram, for example, places electrodes on the skin to record the heart's electrical activity and determine abnormalities. Rogers aimed to take this basic idea dramatically forward to a new frontier.

"The idea of taking rigid, integrated circuit technology and reformulating it—from the bottom up—to allow it to softly wrap around the surface of the brain, meld onto the skin, or form around a beating heart—nobody was doing that," Rogers says. "That's where we saw an opportunity. Moving beyond rigid, point-contact electrodes as interfaces to the body, to fully integrated, soft forms of electronics for drastically increased levels of functionality—blurring the boundaries between biology and electronics."

Rogers and his team discovered that silicon becomes naturally flexible when it's extremely thin. They bonded thin silicon in a wavy geometry to a soft, wavy rubber substrate, which enabled the silicon to twist, bend, and stretch like a rubber band. This set of capabilities opened the door for advanced devices to monitor—and even treat—the heart and brain.

For example, Rogers and longtime collaborator Yonggang Huang, Walter P. Murphy Professor of Mechanical Engineering and Civil and Environmental Engineering at Northwestern, developed an elastic silicon membrane capable of steadying an irregular heartbeat. Such mechanical, electrical, and biomedical feats have earned Rogers a series of prestigious accolades, including a MacArthur Fellowship, the Lemelson-MIT Prize, and election into the National Academy of Engineering and the National Academy of Sciences.

FROM THE CRADLE

Rogers's skin-mounted health monitoring device is now being tested in the neonatal intensive care unit (NICU) at Lurie Children's Hospital of Chicago. His wireless, battery-free, temporary "tattoo" can monitor all vital signs of the most fragile humans in a much gentler way than traditional monitors. Just this summer, Rogers's team finished two rounds of successful testing with human babies in collaboration with Amy Paller, professor of dermatology in the Feinberg School of Medicine.

"If you go into a NICU today, you will see very tiny babies all hooked up with tape and hard-wire connections to external monitoring electronics," Rogers says. "Even the least-adhesive tapes can cause permanent scarring because a baby's skin can be extremely fragile. The wires represent significant mechanical constraints on natural motions. We can get rid of all this hardware and achieve the same kind of measurement functionality with thin, skin-like, wireless, battery-free systems, which also enable the kind of mother-baby interactions that are critically important to healthy development."

AMANDA MORRIS

Photograph by Chris Strong

FIVE THINGS WE CAN

CYBERSECURITY involves more than thinking up complicated usernames and passwords. With many turning to apps and websites for everything from managing their finances to monitoring their health, the risks and consequences of compromised security in the digital realm have never been greater or potentially more devastating.

How secure are you online? Professor Yan Chen suggests five behaviors that can help make you more cybersecure.

1

PRACTICE EMAIL AWARENESS

If you've ever managed an email account, you already know about the inevitable stream of scams that can arrive in your inbox. While messages from desperate "foreign dignitaries" may seem easy to recognize and disregard as phony, many users still fail to practice sound judgment.

Advanced fee scams that ask unsuspecting users for immediate financial payment online in exchange for future riches exist only to enrich the fraudsters who perpetrate them. The ubiquitous "Nigerian prince" email scam duped people out of $12.7 billion in 2013 alone, according to research group Ultrascan AGI.

"Social engineering attacks like email scams remain one of the most common forms of cyber attacks," Chen explains. "People continue to fall victim to emails that appear superficially attractive but are really just asking for your credit card number or acting as a delivery mechanism for installing a malicious email attachment."

To avoid becoming the next victim of an advanced fee scam, Chen recommends against sharing any confidential information by email. With banks, online stores, and other reputable institutions implementing heavily secure online portal systems to conduct customer activity, you're fairly safe in assuming that any email message asking for financial information—no matter how intriguing its reasoning—does so with an ulterior motive.

2

GET EDUCATED

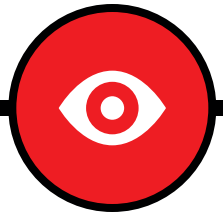
For many users, education is the best defense against cybersecurity risks. Chen notes that increasingly, elementary and high school curricula include cybersecurity lessons for students. That's no surprise. A 2013 study from independent watchdog group Common Sense Media found that nearly three-quarters of children under age eight had regular access to a smartphone or tablet.

Universities have also begun to bolster their course offerings similarly. Northwestern Engineering's Department of Electrical Engineering and Computer Science recently launched its Digital Forensics and Incident Response course, which uses case studies inspired by real cyber attacks to teach students how to recognize and address data breaches.

For those who don't have access to formal cybersecurity education, Chen says that media coverage of cybersecurity news offers an effective crash course. "When news media cover major cybersecurity attacks, they inevitably follow up with security experts who offer recommendations for becoming more cybersecure," Chen notes. "At the very least, you learn how to avoid making the same mistakes as the victims in the news."

DO TO BE CYBERSECURE

3



WATCH YOUR APPS

Consumer research giant Nielsen reports that in 2014, US smartphone users spent an average of 14 hours more per month using apps than they did just two years earlier. As mobile app interactions increase, exposure to pop-up and latent advertising found in many apps poses a growing cybersecurity risk: when clicked, these ads can transport users out of the app and onto the web, where viruses and other malicious content may lie in wait.

Chen recommends practicing caution before clicking on ads within an app—especially ads that ask you to download a program. No app is resistant to linking to potentially malicious content.

To mitigate this risk, Chen and his research team have developed a dynamic detection system for Android phones that pinpoints dangerous ads and reports how they reached the user. While he emphasizes security throughout the app development process, Chen thinks the new technology can help developers address the risk inherent in such advertising.

"Security often lags when there is a rush to get an app or product to market," he says. "Unless developers have witnessed or experienced an attack first-hand, they may remain passive when it comes to incorporating the necessary security measures."

4

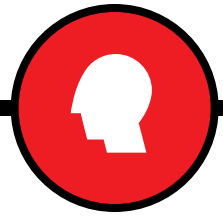
GUARD INFORMATION SYSTEMS

As an individual, you can do little to protect your confidential information from a cyber attack on a retailer that has your data stored in its system. But you can certainly guard your confidential information on a personal level. For starters, Chen recommends maintaining comprehensive virus and malware protection software across all devices, from laptops to smartphones and tablets.

"No protection system is perfect, but many are equipped to recognize and thwart most viruses and attacks," Chen says. "The right software can do a lot of the work for you."

Another way to protect your devices is to exercise diligence when downloading software updates. While it may be tempting to close pop-up windows that notify you about new updates for your operating system or app, Chen says those updates often have as much to do with improving security capabilities as they do with offering new software features.

5



ADOPT A PROACTIVE MINDSET

Beyond developing better personal cybersecurity habits, Chen advocates supporting larger societal efforts to improve the cybersecurity standards at an industry and governmental level. "The challenge of improving cybersecurity isn't a technical one," he says. "There are still advanced attacks targeting large-scale institutions, but they represent a minority compared with overall cybercrime. The majority of attacks target known vulnerabilities for which patches exist. People just don't use them."

Reactively addressing security threats once a product reaches market jeopardizes customers. Instead, companies should emphasize the importance of recognizing vulnerabilities at the outset of development.

Government also has a role to play. In addition to fully enforcing existing cybersecurity protection laws, it can enact new legislation to set even more stringent standards for hospitals, universities, and other major institutions to ensure they have appropriate safeguards in place to protect their very sensitive data.

"It will take time before we can educate everyone about cybersecurity," Chen says. "A new mindset, coupled with improved legislation and better enforcement, can speed up our progress."

Written by Alex Gerage

DATA DIVING TO SAVE CORAL

NEW TOOLS COULD PLAY IMPORTANT ROLE IN THE RACE TO SAVE CORAL REEFS FROM CLIMATE CHANGE

If you're not afraid of ghosts, try visiting the warm, shallow depths of the ocean. What you'll find there should frighten everyone.

Once lush and vibrantly colored, many of these areas are now vast, ghostly graveyards dotted with the brittle skeletons of bleached coral. The reefs the coral formed once teemed with so much life and biodiversity that scientists referred to them as the "rainforests of the sea." Sensitive to temperature spikes, coral reefs now appear a faded, ashen shadow of their former presence. Tragically, they become more endangered by the day.

The culprit in this frightening development? Rising water temperatures resulting from climate change.

TAKING UP ARMS

A Northwestern Engineering research team is now working feverishly to bring these vulnerable communities back from the brink of extinction. By using data to understand what makes certain coral populations more susceptible to collapse, the researchers hope to halt further destruction and breathe life back into the ocean floor.

"Coral is not an independent organism," says Luisa Marcelino, a research assistant professor of civil and environmental engineering. "It depends on the algae that live in its tissue to give it food. High temperatures break up that partnership, and the coral essentially starves."

Marcelino and Vadim Backman, the Walter Dill Scott Professor of Biomedical Engineering, lead an interdisciplinary research team with The Field Museum of Natural History to help combat coral's bleaching crisis. The husband-and-wife team has worked together for years: Marcelino, a longtime diver, uses her background in molecular biology to understand what makes certain coral more susceptible to bleaching. Backman, an expert in cancer diagnostics, uses his disease detection tools to observe the optical properties of coral skeletons.

The pair has now developed two tools to improve understanding and classification of coral: (1) an algorithm that ranks the thermotolerance of coral's symbiotic algae and (2) the first-ever global index of vulnerable coral.

ALGAE ALGORITHM

When coral expels its algae, it is a violent act that leaves behind a stark white skeleton. Interestingly, this does not happen in every case. Some genetic types of algae can tolerate the changing climate's increasing temperature better than others. Coral with thermotolerant algae often recover from bleaching or do not bleach at all. Coral without this hardy type of algae face mortal danger.

"Coral not associated with thermotolerant algae are at the biggest risk," Marcelino says.

Up until now, studying and fully understanding algae's susceptibility to heat have proven incredibly difficult given the more than 400 different types of coral algae and thousands of different coral reefs worldwide. Algae are also notoriously difficult to cultivate in the laboratory.

But finding a solution has become more urgent than ever. The world is currently experiencing the longest global coral bleaching event ever recorded. Knowing which coral colonies are associated with the more thermosensitive algae could help conservationists focus their efforts to curb the crisis.

Combining all algae studies published prior to February 2015, Marcelino, Backman, and their team developed a novel algorithm that ranks which genetic types are the most thermotolerant and which are the most thermosensitive. Using this information, scientists could aid preservation by helping shield sensitive colonies from further risk factors, such as tourism, overfishing, and pollution. Pinpointing the most thermotolerant algae could also help researchers breed more robust coral in the laboratory.

INDEXING CORAL

Ranking the vulnerability of 110 of the most common genetic types of algae, the algorithm serves as a companion piece to Marcelino and Backman's earlier work to standardize measurements of different coral species' vulnerability to thermal stress.

That work established the first-ever quantitative global index detailing which of the world's coral species are most susceptible to bleaching and most likely to die. Based on a massive amount of publicly available, historical data, researchers and conservationists can use the index to compare bleaching responses of corals throughout the world and to predict which corals may be most affected by future bleaching events.

The index, which represents the most abundant species and close to half the world's coral from 316 sites, ranks the corals' susceptibility to thermal stress from 1 to 100, with the most susceptible first on the list. An impressive feat of data science, the index emerged from a meta-analysis of all available historical records on coral bleaching from 1982 through 2006.

"Using very large data sets, we have teased out valuable information that will help researchers identify global trends and learn about individual corals," Backman says. "To make our analysis possible, we applied financial theory conventionally used to predict changes in stock prices in response to stock market variations to model how individual corals react to a change in the environment."

Although coral bleaching is occurring to an unprecedented degree, the researchers remain hopeful that their data can make a difference. Timothy D. Swain, a research associate in Marcelino's laboratory and first author on both studies, says, "Coral bleaching is an inescapable example of the effects of climate change. We can see it with our eyes, and we also clearly see the progression of climate change in our data. Our goal is to use the data to understand what drives bleaching and to learn how we can protect the world's coral reefs."

AMANDA MORRIS

IDEAS AT THE INTERSECTION

INNOVATIVE IDEAS LIE AT AN EXTRAORDINARY INTERSECTION: THE INTERSECTION OF DISCIPLINES, OF POINTS-OF-VIEW, OF UNDERGRADUATE AND GRADUATE EDUCATION, OF THOUGHT AND ACTION.

Northwestern Engineering students thrive at this intersection. Through research, entrepreneurship, and design thinking, students move beyond theory into implementation as they tackle problems both known and not yet imagined. Spinning innovation out of courses and student groups and from the creativity and ambitions of self-assembled teams, students present new products, apps, and systems in areas as diverse as healthcare, energy, and environment. Take a peek at some of our projects to find out not what's happening *now*, but what's happening *next*.

Our new website, **Ideas at the Intersection** (ideas.northwestern.edu), showcases recent innovative, interdisciplinary student projects.

Developed through the Innovation Fellowship of the Center for Device Development (CD2), Bold Diagnostics aims to redefine how patients measure their blood pressure by integrating an innovative hardware and software system into their everyday routines.

BOLD DIAGNOSTICS

"While current modern fitness trackers record health-related measurements like heart rate, Bold Bands is one of the first wearable technologies to provide accurate and real-time blood pressure data, which is vital for helping doctors diagnose and treat patients with cardiovascular disease."

Kyle Miller
co-founder of Bold Diagnostics

★ BENEFITS

- Provides a comfortable, unobtrusive alternative to current devices
- Offers real-time monitoring of a patient's condition
- Reduces the risk of misdiagnosis from inaccurate readings

Founded by students at the McCormick School of Engineering and Applied Science and the Kellogg School of Management, IFM Technologies is a startup developing intelligent drones specializing in automated indoor construction site inspections.

INTELLIGENT FLYING MACHINES

"Similar to Google Street View, our platform enables remote walkthroughs of indoor spaces—imagine the CEO of a company sitting in his office in Chicago while walking through his company's construction site in Miami, all without leaving his desk."

Marc Gyongyosi IFM Technologies co-founder

Problem ▸ Construction site inspection, a highly hands-on task, requires workers to take and send photos to stakeholders to review progress. Current inspections are slow and expensive—$55 billion is spent every year to fix errors from poorly completed ones.

Solution ▸ Intelligent Flying Machines's flying robots autonomously capture accurate positioning data from indoor environments using onboard cameras, embedded NVIDIA GPUs, and computer vision algorithms. The lightweight drones complete inspections faster, more accurately, and less expensively than current alternatives.

Process ▸ The company formed following two years of research and iterating autonomous indoor drones. Developers flew prototypes at test sites to determine the market segment that would benefit most from the technology.

★ BENEFITS

- Automates data capture in indoor spaces
- Allows for remote walkthroughs of construction sites
- Suggests points of interest and detects hazardous objects

STATUS

IFM Technologies is testing its drones as one of several pilot projects across different industries, which they hope will establish their startup as the standard for accuracy and reliability in automated indoor scene inspection. The team plans to finish the pilots by fall 2016, when they will turn their attention to producing a commercial version of their drone for release in 2017.

IFM-TECH.COM

CO-FOUNDERS

Marc Gyongyosi
computer science

Siddarth Jain
computer science

Nathan Matsuda
computer science

Justin Saeheng
Kellogg School of Management—MMM Program

How It Works ▸ Bold Bands, a wearable device that resembles popular activity trackers, uses sensors placed on the wrists, rather than the commonly used sensing cuff, to measure blood pressure. The system monitors trends based on differences in the pulse wave transit time between the two hands. Reports can be sent to electronic medical records so doctors can study a patient's blood pressure under non-clinical conditions.

In Search of a True Need ▸ To align fully with the CD2 Innovation Fellowship's goal to commercialize an innovative technological device, the team sought to identify a significant unmet clinical need. Team members took advantage of their observation privileges at Northwestern Memorial Hospital to hone in on hypertension measurement after learning about the difficulties of acquiring accurate blood pressure data from patients using bulky, cuff-based machines.

STATUS

The team received a National Science Foundation Small Business Innovation Research grant worth $225,000 to advance its technology and build a next-phase prototype, with hopes of offering one of the first cuffless blood pressure monitors to consumers.

PROGRAM

Center for Device Development Innovation Fellowship

BOLDDIAGNOSTICS.COM

TEAM

Sean Connell, PhD
biomedical engineering

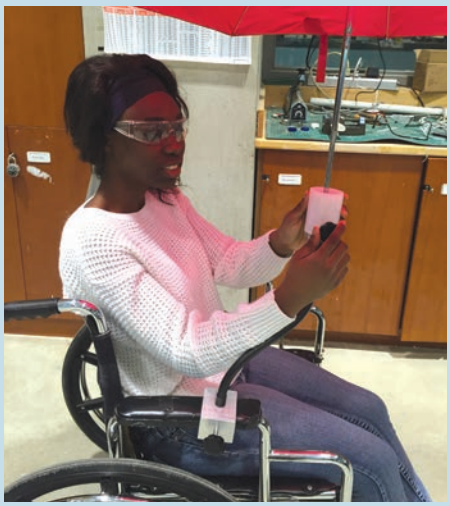
Kyle Miller, MD, MBA
manufacturing and design engineering

Jay Pandit, MD
Feinberg School of Medicine

Andrew Wu
biomedical engineering

As part of their first-year Design Thinking and Communication (DTC) course, four freshmen collaborated on a project to help residents at Chicago-based Eden Supportive Living pursue outside activities despite their mobility issues and regardless of weather conditions.

FLEXIBRELLA



Problem ▸ For those who rely on mobility aides like walkers and wheelchairs, inclement weather can hinder their ability to travel to the grocery store, visit a friend, or complete any number of other daily tasks.

Solution ▸ The simple, intuitive device attaches to wheelchairs and walkers, adjusting to different angles and heights to shield users from rain, snow, or even sun. The design includes a U-channel with a screw to attach the Flexibrella to the wheelchair and a cup with screws to hold the umbrella.

Process ▸ After an initial mockup made of cardboard and PVC pipe failed performance testing, the team applied more durable materials: a sturdy gooseneck arm, a plastic cup with a Plexiglas base, and a clamp-like aluminum device.

"Although simple, Flexibrella enables people who use wheelchairs to go about their daily activities without having to worry about the weather. A small change, for sure, but hopefully impactful."

Amanda Mirande Flexibrella team member

STATUS

The final Flexibrella prototype is currently in the hands of Eden Supportive Living, where residents who use it are encouraged to contact the Flexibrella team with feedback and ideas.

COURSE

Design Thinking and Communication

TEAM

Amanda Mirande
chemical engineering

Evan Tang
computer engineering

Whitney Tesi
industrial engineering, economics

Nancy Yao
computer engineering

COMMUNITY PARTNER

Eden Supportive Living

Tired of the same, boring food options on campus, an interdisciplinary student team in the NUvention: Web + Media class aims to change the competitive food delivery market. They propose to give customers new options at a better value by partnering with restaurants to offer delivery without fees.

FOODROP

How It Works ▸ Each day, Foodrop's featured restaurant offers a limited number of menu items. Subscribers place orders by a cutoff time, giving the restaurant time to prepare the food. Meals are then delivered to one spot on campus for pickup.

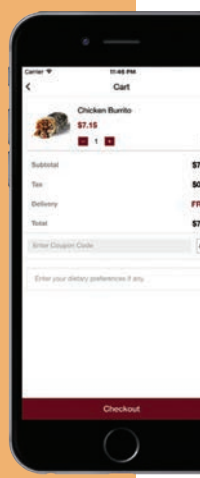
From Food Boredom to Food Hero ▸ The team brainstormed ideas in the domains of education and financial services, but no one felt excited. They soon found inspiration talking about a problem they all experienced—food boredom.

"People visit the same restaurants day after day and week after week. We wanted to introduce more variety at better costs."

Kunal Dalvi cofounder of Foodrop

STATUS

Foodrop plans to launch campus wide at Northwestern in the fall and eventually expand to corporate offices and hospitals in downtown Chicago.



TEAM

Kunal Dalvi
Kellogg School of Management

Jack Qiu
computer science

Andrew Yang
computer science

Kristen Zhou
Kellogg School of Management—MS in Engineering Design and Innovation

★ BENEFITS

- Restaurants offer discounts in exchange for the new business
- Customers have more order options
- Menus rotate weekly to include more variety
- App allows groups to split checks easily

When Procter & Gamble decided to reimagine laundry as a less tedious task, it turned to Northwestern's Master of Science in Engineering Design and Innovation (EDI) program. The result: Tide Spin, an app-based service that outsources the chore to cleaners at Tide dry-cleaning facilities.

TIDE SPIN

STATUS

The service is currently being tested in Chicago. The Tide Spin app can be downloaded at Google Play and the iTunes App Store.

★ BENEFITS

- Free delivery and no minimum order
- Users select the scent of the detergent and fabric softener used
- If clothes are lost or damaged, Tide Spin covers their cost
- Cleaning process is environmentally safe
- Expected turnaround time is two days

"Millennials are becoming more and more open to outsourcing all mundane tasks."

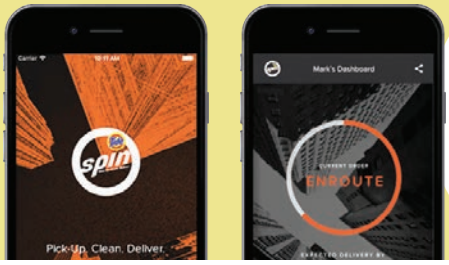
David VanHimbergen brand manager of Global Tide, CEO of Tide Spin

TEAM

Kristine Oak, James Wilde, Esther Wolff
all EDI Students

How It Works ▸ Tide Spin does customers' laundry at its own dry-cleaning facilities staffed by Tide-trained professionals. Customers schedule service through an app, then a van picks up their laundry and dry cleaning, takes the articles to be expertly cleaned, and returns them.

Process ▸ The teams decided on a business model after observing people doing laundry, interviewing potential users, studying the interpersonal dynamics of doing others' laundry, prototyping environments, and testing logistics.



Sponsored by PACE (Partners for the Advancement of Collaborative Engineering Education), four students enrolled in a Segal Design Institute capstone course spearhead the design of the expansion mechanism for a Reconfigurable Shared-Use Mobility System (RSMS)—a transforming automobile.

TA-DA

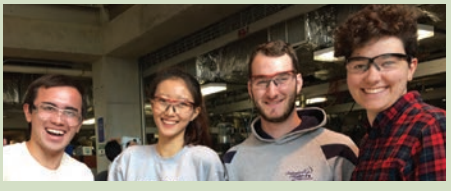
"Traditional transportation systems have a large environmental and social impact on urban areas. To disrupt these systems, we aim to redefine how we interact with cars."

Sally Park TA-DA team member

Problem ▸ The average American car sits unused for about 95 percent of the day, a big contributor to transportation inefficiency, especially in dense urban areas.

Solution ▸ Working with partner universities from around the world, the Northwestern team led the design of TA-DA, an expandable electric car that promotes car sharing by reconfiguring into different multipurpose rooms at the push of a button.

Process ▸ Overcoming language and geographic barriers, the Northwestern students communicated with their global partners multiple times each week to advance the vehicle's design.



PROGRAM

BS in Manufacturing and Design Engineering

TEAM

Elizabeth McTighe
mechanical engineering, MaDE

Matthew O'Hagan
mechanical engineering, MaDE

Sally Park
MaDE

Eric Willms
mechanical engineering

STATUS

TA-DA received the RSMS Overall Award at the 2016 PACE Annual Forum competition and first-place recognition in the industrial design, product engineering, and manufacturing categories. The team is currently working to integrate its finalized expansion system design into the frame developed by collaborators at Hongik University in South Korea.

WE WILL.

THE CAMPAIGN FOR NORTHWESTERN

Northwestern University launched the multi-year We Will campaign in March 2014. Here are some recent notable gifts to Northwestern Engineering's campaign.

NEW MAJOR GIFTS

In honor of Northwestern professors John E. Hilliard and Joan M. Whitten, **Walter M. Yang** and **Christine L. Yang** pledged $250,000 to establish the Walter M. Yang (PhD '71) and Christine L. Yang (MS '69) Endowed Fund in support of graduate student recruitment in the areas of nanotechnology, materials science, and microbiology.

Stephen H. Carr, professor of materials science and engineering and chemical and biological engineering, and his wife **Virginia McMillan Carr** (WCAS MS '71, PhD '76), retired research scientist in the Weinberg College of Arts and Sciences' Department of Neurobiology and Physiology and the Feinberg School of Medicine, pledged $125,000 to establish the Stephen and Virginia Carr Undergraduate Endowed Fellowship Fund and the Stephen and Virginia Carr Undergraduate Expendable Fellowship Fund in support of undergraduate engineering research.

David B. Larimore ('68) pledged $100,000 to establish the David B. Larimore Engineering Scholarship Fund in support of undergraduate engineering students. Larimore has also made provisions in his estate plans to support the fund in the future.

The Simons Foundation appointed Madhav Mani, assistant professor of engineering sciences and applied mathematics, as a Simons Investigator in the Mathematical Modeling of Living Systems with a $660,000 award to Northwestern University.

If you would like to join in making a special gift to the campaign, please contact Patrick Hankey, development director, at 847–467–2950 or patrick.hankey@northwestern.edu.

CLASS NOTES

OF ALES, PORTERS, AND STOUTS

DAVE BURNS ('95, MS '96, AND KELLOGG '02) DRIVES LAKE BLUFF BREWING FROM PERSONAL VISION TO AWARD-WINNING ENTERPRISE.

"Without any formal culinary background, it was definitely the process orientation I learned while studying engineering at Northwestern that put me in a position to succeed with brewing."

Had Dave Burns known back in 2011 what the Lake Bluff Brewing Company would become, he confesses he might have done things differently when launching the microbrewery.

"This was all about providing good beer for our friends and neighbors in a comfortable, relaxed setting," Burns says. "It was supposed to be a hobby on the side. It became a real business with serious legs."

In fact, since Burns co-founded the Lake Bluff Brewing Company five years ago, it has continued to attract a loyal and growing following in Lake Bluff, a cozy Chicago suburban bedroom community of some 5,700 residents located about 20 miles north of Burns' alma mater in Evanston.

The microbrewery has also gained national recognition. In 2013, Lake Bluff Brewing captured a gold medal at the United States Open Beer Championships for its Kosmonaut Russian Imperial Stout, a hearty brew aged in whiskey barrels and named after Burns' beloved dog, Kosmo. In succeeding championships, the microbrewery scored bronze medals for its Velvet Hammer Imperial Vanilla Porter in 2014 and for its Gamma Ray American Pale Ale in 2015.

"This was certainly beyond our expectations," Burns says.

Back in 2009, when Burns and his home-brewing neighbor Rodd Specketer first discussed opening a microbrewery while sampling home-crafted beers around a fire pit, their vision was less about launching the next Sierra Nevada or Sam Adams and more about sharing one-of-a-kind concoctions with the locals.

"We thought a microbrewery could add to the vitality of our community. That was really the beginning as we saw it," says Burns, who studied mechanical engineering at Northwestern and now works as a project manager at pharmaceutical company AbbVie.

As the two friends' budding venture unfolded, Specketer, a financial pro by trade, handled front-of-the-house duties, while Burns managed back-of-the-house operations, including brewing novel beers.

"Without any formal culinary background, it was definitely the process orientation I learned while studying engineering at Northwestern that put me in a position to succeed with brewing," says Burns. "From time to temperature, acidity to ingredients, you change just one little thing and it's a different result." It was also at Northwestern that Burns met his wife, Nisha ('96, Kellogg '02), a chemical engineering major.

Respecting the rich traditions of craft brewing while keeping pace with the fast-changing industry, Lake Bluff Brewing gained an enthusiastic following for its "foundational beers" as well as its "Brewers handles," the rotating specials that showcase the microbrewery's creativity.

Finding the establishment more of a tasting room than a full-fledged restaurant—there are only 30 interior seats, a small patio, and no in-house foodservice—the local crowd began referring to Lake Bluff Brewing Company as "our place."

"And, honestly," Burns admits, "that's all we ever wanted."

In early 2016, Burns recognized that the microbrewery, with its swelling fortunes, had become a far larger endeavor than he ever imagined. The timing to sell was perfect, so he and Nisha, an AbbVie marketing executive who had helped concept the early branding efforts, sold their ownership stake to the establishment's master brewer.

"It was time," Burns says, "and I'm proud of what we created and excited to see how the new blood takes it to the next level."

DANIEL P. SMITH

A Winding Road to Success

ENTREPRENEUR **DAVID PESSIS** (MSIT '09) JUGGLED GRADUATE STUDIES AND A STARTUP LAUNCH BEFORE HELPING GUIDE POINTDRIVE TO A SUCCESSFUL ACQUISITION.

"I FELT PRETTY GOOD ABOUT THE TECH SIDE, BUT LEARNING ABOUT MARKETPLACE POSITIONING AND CUSTOMERS, CASH FLOW STATEMENTS, AND BALANCE SHEETS MADE ME MUCH MORE EFFECTIVE."

Crazy. That's how David Pessis describes his decision to enroll in Northwestern's Master of Science in Information Technology program and to launch a new business venture simultaneously.

"People say entrepreneurs are the dumbest smart people in the world because they don't know what they're up against," Pessis jokes. "I guess that's me."

In late 2007, Pessis launched Fippex, a cloud-based client enablement and communications platform built initially for private equity firms and hedge funds. At the height of the financial crisis and amid the fallout from scandals triggered by the likes of Bernie Madoff, Fippex promised to inject transparency into the marketplace by allowing investors to see the real-time status of their investments.

For Pessis, Fippex became a religion, consuming his hours and his heart. "I lived and breathed it every day," he says. With his graduate program's business courses to inform his entrepreneurial efforts, Pessis says, "I felt pretty good about the tech side, but learning about marketplace positioning and customers, cash flow statements, and balance sheets made me much more effective."

Delivering custom, big-enterprise deployments fueled by the system architecture skills of Aly Boghani (MSIT '07), Pessis's fellow Northwestern Engineering alum, Fippex gained traction quickly, earning the business of leading private equity firms and international banking giants.

Energizing as that was, Pessis and his Fippex colleagues recognized an even greater opportunity: spinning that kind of transparency from the realm of finance to sales.

In June 2013, Fippex reincarnated and rebranded itself as PointDrive, a sales-oriented application designed to help sales teams package, personalize, and share digital content—files, links, videos, and more—with prospective customers. The PointDrive system also included analytics to identify the most relevant content for streamlining a successful sales cycle.

"This opened up a whole new world for us," Pessis says. PointDrive quickly earned acceptance by top real estate firms and sales organizations, including LinkedIn, which saw so much potential that it acquired the company in July 2016. As the social networking powerhouse performed its due diligence en route to closing the deal, Pessis relished—albeit sometimes anxiously—the trip "down memory lane," reliving the milestones and missteps of his startup's winding, nine-year journey.

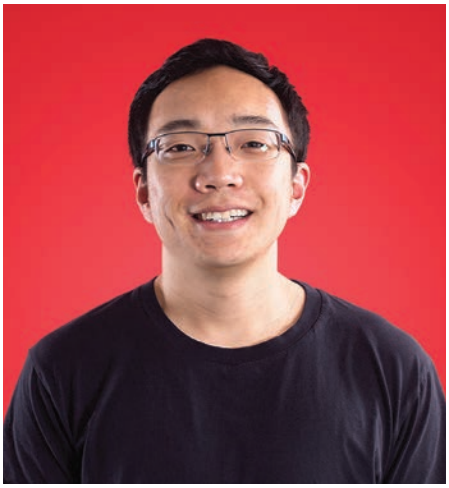
"You make thousands of mistakes as an entrepreneur since you are doing so many new things," says Pessis, who joined Amazon Web Services in Seattle in 2013 but remained a member of the PointDrive board. "I'm so grateful we had a successful exit; I know that's not the case for most entrepreneurs."

Pessis acknowledges that a little crazy in the entrepreneurial life goes a long way, but still says, "Honestly, I can't wait to do it again."

DANIEL P. SMITH

AT PLAY IN THE SPACE BETWEEN DIGITAL AND REAL

WITH A PASSION FOR TANGIBLE DIGITAL DESIGN, **FELIX HU** ('14) MOVES FROM RESEARCH TO REALITY WITH A GAME THAT TEACHES KIDS TO CODE.



"RESEARCH PROJECTS OFTEN START AND END IN THE LAB, SO IT'S BEYOND EXCITING TO HAVE RESEARCH COME TO LIFE AND BRING KIDS JOY."

In his first years as a computer science major, Felix Hu ('14) envisioned a career in big data or machine learning.

Then, Data as Art happened.

A collaboration between Northwestern and the School of the Art Institute of Chicago (SAIC), this innovative course challenges students to translate complicated information into visual art or images for the masses.

For Hu, it also ignited a passion for tangible digital design and launched a journey that resulted in Osmo Coding, a recently released game that helps children learn the basic concepts of computer programming.

"The space between the tangible and the digital is such an interesting area to explore because there's so much to discover," Hu says.

While taking Data as Art during the summer prior to his senior year, Hu and SAIC student Ariel Zekelman began exploring different tangible design products. They continued their search after completing the course, and as Hu neared graduation, he contacted Mike Horn, associate professor of electrical engineering and computer science and leader of Northwestern's Tangible Interaction Design and Learning (TIDAL) Laboratory, to inquire about ongoing projects.

"I didn't think [Professor Horn] would even reply to me," Hu confesses.

But Horn did just that, eventually pulling Hu into Strawbies, a tangible design project focused on developing a game to teach elementary school children the building blocks of coding.

Working his day job at a consulting firm, Hu devoted nights and weekends to developing Strawbies. In the game, children play and learn by arranging encoded tiles in front of an iPad. The tablet's camera perceives and interprets the physical tiles' arrangement and, through Hu's programming code, helps Awbie, a digital character on the screen, interact with his animated world.

Hu, Horn, and Zekelman, an industrial designer charged with the game's tangible element, spent months exploring different approaches for the iPad app and the programming tiles. They also tested the game extensively with children, parents, and teachers to ensure it was inviting, open-ended, and engaging. Hu would often observe students at play one day, make tweaks that evening, and return the following day with an update.

Horn acknowledges, "Felix was the engine here, and he attacked the project with a drive and enthusiasm that made it happen."

In September 2015, the trio ventured to Silicon Valley for a meeting with Tangible Play, a startup focused on educational games. Tangible Play's leaders liked Strawbies so much they offered to buy it and to hire both Hu and Zekelman.

"It was great validation of our work," Hu says.

Renamed Osmo Coding, the game, which blends digital and physical play, launched publicly in May 2016 and generated favorable press from no less than *The Wall Street Journal* and *Forbes*.

"It was an absolute whirlwind," says Hu, who continues releasing new content for Osmo Coding while helping Tangible Play conceptualize new games.

Reflecting on the enthusiastic acceptance of the game by both children and their parents, Hu notes, "Research projects often start and end in the lab, so it's beyond exciting to have research come to life and bring kids joy."

DANIEL P. SMITH

Photograph courtesy of Tangible Play

SHAPING THE FUTURE OF MATERIALS TECHNOLOGY

AT TESLA MOTORS AND SPACEX, **CHARLIE KUEHMANN** (PHD '94) IS DRIVING MATERIALS ENGINEERING INTO THE FUTURE.

Like most kids growing up during the era of NASA's Apollo space program, Charlie Kuehmann wanted to be an astronaut. He remembers sitting in front of the television as a five-year-old, watching Americans launch into outer space and knowing that he wanted to be part of that. But when he lost fingers on one hand in a childhood accident, he feared the dream might end.

"Back then, all the astronauts were Air Force pilots, and I knew that [my physical limitations] would keep me out of it," he shares.

"So I thought, OK, if I'm not going to be an astronaut, then I want to build the rockets that go up there."

From that point on, he knew his calling was to be an aerospace engineer. "I just kept going for it, and it worked out pretty well," he says.

Today, as vice president of materials engineering at SpaceX and Tesla Motors, Kuehmann drives development of materials innovations that could one day help enable the commercialization of space and the colonization of other planets. Each time SpaceX launches a new rocket, he and his team study how well it worked, reviewing what was successful and fixing what wasn't.

"I'm sure that's what the Apollo program engineers were all about," he says. "Today we're putting together stuff and making sure it works, just like I'm sure they did back then. It's really incredible."

FOCUSING ON THE GOAL

Looking beyond successes and setbacks to stay focused on what you want to achieve is a lesson Kuehmann learned at Northwestern while earning a PhD in materials science and engineering. But he first began to think about materials while interning at Honeywell and General Dynamics as an aerospace engineering undergraduate at Arizona State University.

"In each of the projects I worked on, success depended on how the materials performed," he remembers. "I thought if you could push the performance of the materials, it was a really big knob to turn to improve what you were designing."

One of his ASU advisers, a Northwestern alumnus, recommended he check out Northwestern's programs. After earning a National Science Foundation graduate research fellowship, he decided to pursue a PhD.

"I picked Northwestern because when I talked to the professors, I really enjoyed how collaborative they were," he recalls. "It seemed like the projects were more broad-based and interesting."

One of the professors he worked closely with was Gregory Olson, Walter P. Murphy Professor of Materials Science and Engineering. Dubbed the "father of materials design" by the American Academy of Arts and Sciences, Olson had come to Northwestern from MIT just as Kuehmann started. The two discussed Olson's vision for using computational modeling to improve materials design. This struck a chord with Kuehmann, who had experience in design and computational modeling for aerospace systems.

"I felt that was something I could bring to the table, and at the same time I could learn a tremendous amount from this guy who was brilliant in materials science and thought about materials in a way that was pretty unique," he says.

When Olson asked him to grab a beer while they talked about the topic, Kuehmann knew they would collaborate well. "If you're going to spend five years on your PhD, you better find somebody you enjoy working with," he laughs. "I realized he was somebody I could deal with for a long time, but I didn't know *how* long I was getting in for."

"IN EACH OF THE PROJECTS I WORKED ON, SUCCESS DEPENDED ON HOW THE MATERIALS PERFORMED. I THOUGHT IF YOU COULD PUSH THE PERFORMANCE OF THE MATERIALS, IT WAS A REALLY BIG KNOB TO TURN TO IMPROVE WHAT YOU WERE DESIGNING."

MATERIALS BY DESIGN

The two ended up working together for 18 years after founding QuesTek Innovations, an integrated computational materials engineering firm, in 1996. They used the revenue stream from an engineering and technical services company Kuehmann had started as an entrepreneurial-minded undergraduate to help fund QuesTek, combining the two companies.

"Charlie was an unusual student," Olson says. "He entered materials science graduate studies with a strong background in engineering design through his undergrad studies in aerospace engineering and his prior entrepreneurial experience. He was the perfect candidate to commercialize the materials design technology his doctoral studies helped create."

QuesTek used proprietary expertise to rapidly design, develop, and insert new materials with specific properties to reduce costs and improve performance. Clients included Newman/Haas Racing, the US Navy, and SpaceX. Kuehmann served as QuesTek's CEO until he and Olson sold the company to an unnamed buyer in 2012.

While Kuehmann continued to serve on QuesTek's board of directors, he moved on to become director of product design at Apple Inc., where he headed up a materials engineering team that worked across product lines. Going from running his own company to working for a major brand was a big change, but he says the atmosphere at Apple was very entrepreneurial, and the job was essentially the same.

"My product was no longer the main product, but in a lot of ways it wasn't that much different," he explains. "It was building a team to do a particular job."

A HIGHER CALLING

Kuehmann enjoyed the role at Apple, but the kid inside him still wanted to make rockets. At QuesTek, he'd worked with SpaceX's engine propulsion team, and although he didn't meet Elon Musk, the Tesla Motors and SpaceX founder and CEO had heard good things about Kuehmann's work. One day, Musk called him.

"Elon has always been a strong supporter of advanced materials," Kuehmann says. "He's very much an engineer and recognizes how much materials have to play in that, so he was thinking about upping their game. We talked about it, and it became clear that both Tesla and SpaceX need a design-centered approach for materials. It made a lot of sense that I lead both sides of the fence."

At Apple, Kuehmann helped create products that impact people's daily lives. At Tesla and SpaceX, he's making products that he hopes "will lead to human achievements that people will talk about forever," much like the Apollo missions. He thanks Northwestern for his involvement in shaping new materials technology that was 20 years ahead of its time. He stays connected, often speaking to students and serving on the advisory board of Olson's research group in the Materials Technology Laboratory.

"The government's Materials Genome Initiative is basically saying what we did 20 years ago at Northwestern is the future of the way materials are going to be engineered," he says. "Every day, I'm creating what I learned at Northwestern in new organizations, and that's really satisfying."

SARA LANGEN

INVESTED IN TECHNOLOGY

VENTURE CAPITALIST AND TELECOMMUNICATIONS PIONEER **PRISCILLA LU** (PHD '80) IS ADVANCING INNOVATIONS IN CHINA'S HEALTHCARE TECHNOLOGY AND CLEAN TECH SECTORS.

As world markets began sliding toward financial crisis in 2008, Priscilla Lu sensed trouble in the air. She was adept at reading market trends, having spent five years helping make sound investments in China for the Mayfield Fund, a Silicon Valley-based venture capital firm. To ride out the coming storm, she knew she needed to redirect and spearhead new efforts in two areas with tremendous opportunities: healthcare and clean technology.

As founder, general partner, and managing director of Cathaya Capital, Lu looks back on that time as a key inflection point in her career, when she moved from more technical and operational thinking to applying financial acumen. "Despite the financial crisis, I was fortunate enough to establish the fund in the beginning of 2009," Lu remembers, noting that the European family fund that committed $200 million in investment capital recognized the investment opportunities and growth in these sectors in China.

"We were looking at improving hospitals in China and training their staffs to utilize more advanced technologies for diagnostics and patient therapies, especially in oncology and cardiology," she says. "I felt that was an area where there was a growing need, and where the investments could make a difference in contributing to the advancement in medical care for the communities."

The clean tech sector also cried out for investment to help mitigate pollution and reduce the country's dependency on fossil fuels. Lu used her cross-border expertise and connections to help Chinese companies establish partnerships with Silicon Valley companies that had proven success in these areas.

"That was the formula, finding the right combination that would help grow the two sectors quickly and fulfill a very dire need in China for industries to address these needs," she says.

A passion for innovation, a catalyst for change

Using her capability and experience to maximize opportunity has been the secret to Lu's success. As a high school student in Hong Kong, she quickly recognized that the emerging computer science discipline offered a chance to blend her interests in mathematics, physics, and analytics.

"Computer science was just becoming mainstream as an area of concentration for studies," she remembers. "What interested me was the challenge of solving problems methodically."

After earning a BS and MS in computer science and mathematics from the University of Wisconsin, Madison, Lu joined AT&T Bell Laboratories in Naperville, Illinois, in 1976. She describes it as a major center of excellence for technology breakthroughs with a unique atmosphere that encouraged inventiveness and exploration.

"It was an extremely exciting and exhilarating environment," she recalls. "Innovation could be quickly implemented in practical and revolutionary applications that made a huge difference in advancing various areas of technology."

The company offered her the chance to earn a PhD from Northwestern. Lu found her job and her studies so engrossing that she spent all of her time in the lab, often working until dawn, fueled by the energy of the professors and students around her.

"When you're interested in something, your mind just doesn't stop," she laughs. "There's no need to rest because you're not tired."

After earning her PhD in computer science and electrical engineering, Lu thrived in the incubator environment at Bell Labs, leading efforts in digital switching and networking and developing the early technologies for microprocessors. During her 16 years there, she worked her way up to become director of the imaging and multimedia lab.

When Bell Labs spun off to become Lucent in the mid-1990s, Lu was heartbroken. Sensing that the culture would change, she decided to go to Silicon Valley and try her hand there. She says one of the keys to her success has been to step out of her comfort zone and embrace change. "I felt the only way I could continue that creative innovation was to be in Silicon Valley in an environment similar to Bell Labs, but in a more unstructured way—not in a corporation, but in a community," she says.

Embracing challenges and transformation

Relying on her telecommunications expertise, Lu decided to launch interWAVE Communications in 1994, a startup providing mobile networks in developing countries. As the founder, chairman, and CEO Lu felt proud; not many women were starting technology companies at the time.

Building cellular networks in countries with rugged terrain, primarily in Africa and where most people didn't have traditional phones, let alone cellular technology, proved tricky but rewarding. Lu found the challenge invigorating and was pleased at its positive effect on the economic development of local businesses.

"Those markets were ready for wireless cellular networks," she remembers. "The growing businesses in those countries all needed phones, and it was easier to deploy wireless telephones and avoid the burden of laying out wires and conduits."

Securing funding from Mayfield and Morgan Stanley Ventures, Lu built interWAVE from the ground up. The company went public in its sixth year, achieving multi-billion dollar market capitalization and delivering more than 160 networks throughout Africa and the Middle East.

"Computer science was just becoming mainstream as an area of concentration for studies. What interested me was the challenge of solving problems methodically."

"Even as CEO of my company, I continued to pursue technical innovation, with more than 20 patents in cellular networking," she says. "Often engineers think that by becoming a manager or becoming more focused on the financial side of the business, the technical innovation stops, but that's not true."

Eye on investing

After 10 years of success with interWAVE, Lu craved a new challenge. In 2003, she became an adviser to Mayfield Fund and helped found the Golden Sands River Venture, a venture capital fund overseeing more than $1 billion in investments in China. With the expertise she gained there, she was able to launch Cathaya Capital in 2009. Using her experience in high-tech investment and her operational experience as a CEO, she then joined Deutsche Bank and established the new Sustainable Investment group for Asia.

She is now general manager and regional officer for asset management for the region, where she focuses on investments in clean energy and environment-related companies.

Shifting her focus from developing and disseminating new technologies to funding the companies creating the next tech breakthroughs was a natural progression for Lu. Her experience running her own startup gives her insight to identify teams and companies with potential and the operational know-how for successful business models and partnerships.

"If they are missing certain elements in the team dynamics, or if they need significant partnerships to meet their target objectives, mission, and vision, I can help them develop that and guide them on adopting sound business models and operational plans," she says.

Lu says that at Northwestern, she learned the value of strong interdisciplinary partnerships and the curiosity to pursue information beyond her knowledge base, and developed the belief that learning never stops, which is why she serves on the McCormick Advisory Council. She hopes to impart this continuing pursuit for knowledge to young engineers.

"Northwestern taught me how to go beyond what you already know and still feel comfortable, knowing that the more you learn, the more you can benefit and expand your abilities."

IN MEMORIAM

CHRISTINA ENROTH-CUGELL

Distinguished Vision Scientist

Christina Alma Elisabeth Enroth-Cugell, emeritus professor of biomedical engineering and neurobiology, passed away June 15 at age 96. She will be remembered as a renowned vision scientist, distinguished researcher, and compassionate colleague.

Arriving at Northwestern in 1955, Enroth-Cugell worked as a research fellow and instructor in the University's Department of Ophthalmology before transitioning to the Department of Physiology faculty. In 1968, she began a joint appointment between the Weinberg College of Arts and Sciences and the McCormick School of Engineering, becoming one of the first female Northwestern faculty members to teach engineering.

A celebrated researcher, Enroth-Cugell made notable contributions in the areas of visual adaptation and the spatial and temporal aspects of receptive fields and was at the center of the study of vision at Northwestern. After her retirement in 1990, she continued to play an active role in her lab, which served as a vital hub in the development of many of today's vision scientists.

JAMES VAN NESS

Emeritus Professor and Alumnus

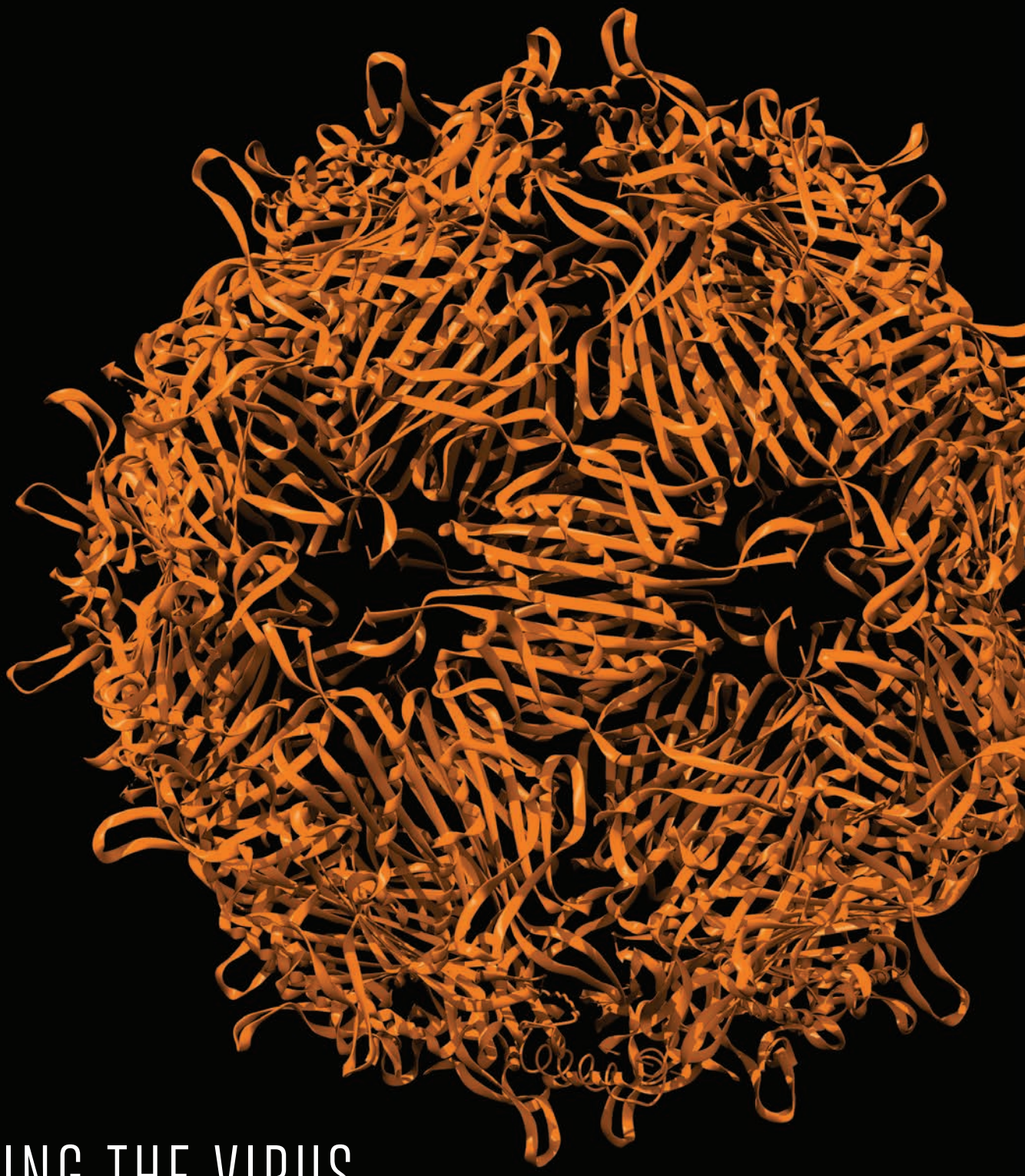
James E. Van Ness (MS '51, PhD '54), emeritus professor of electrical engineering and computer science at Northwestern University, passed away at age 90 on September 9 after a long illness. He will be remembered as a devoted teacher, valued mentor, and friend.

A member of Northwestern's faculty since 1952, Van Ness made major contributions to the area of large-scale networks, including early computer systems and the power grid. His work was a driving force in bringing high-performance computers to Northwestern in the 1970s—when computers were so massive they required their own buildings. In 1988, he was elected to the National Academy of Engineering, which cited his pioneering work in developing computer algorithms used in the design and operation of electrical power systems.

His earlier service in the US Navy working with radar equipment on an aircraft carrier inspired his interest in electrical engineering. When his naval service ended, Van Ness enrolled at Northwestern and earned his master's degree and then PhD in electrical engineering. Even before completing his PhD, he joined the University as a lecturer in 1952 and later became a full professor.

Mr. Jerome B. Wolff '38
Mr. Kenneth G. Halvorsen '44, MS '49, PhD '51
Mr. Arthur M. Koblish '45
Mr. Frederick E. Nagel '45
Dr. William V. Pietsch '45
Mr. Burton H. Pearson '46
Mr. Donal D. Guffey '47
Mr. Robert A. Lehl '47
Mr. John N. Duval '48
Mr. Donald G. MacLean '49
Mr. Robert E. Moore '49
Dr. Gino Sovran '49
Mr. George P. Walling '49
Mr. Edmund G. Astolfi '50
Mr. Arthur E. Carlson, Jr. '50
Mr. William J. Davis, Jr. '50, MS '51
Mr. Robert H. Harner '50
Mr. Robert W. Semmler '50
Mr. James P. Burelbach '51
Mr. D. Eugene Nugent '51
Mr. Roger T. Struck '51
Mr. John A. Swider '51
Mr. James E. Van Ness, MS '51, PhD '54
Mr. Charles E. Altmeyer '52
Mr. Robert E. Jelinek, Jr. '52, MS '54
Mr. David R. Thomas '53
Mr. Donald J. Zale '53, KSM MBA '57
Mr. Charles A. Hedges '54
Mr. George A. Johnston '54
Mr. Alan C. Skinrood '54, MS '56
Mr. Elmer E. Goshorn '55
Mr. Delmar R. Johnson '55, MS '57
Mr. David M. Paynter '55
Mr. Robert D. Phillips '55
Mr. Eo Vaher '55
Mr. Ronald W. Anderson '56
Mr. James W. Jones '56
Mr. John F. Seidensticker '56, MS '57
Mr. Quentin F. Ingerson '57
Mr. Albert F. Lueck, Jr. '58
Mr. Francis K. Reed '58
Mr. Arthur E. Ritter '59
Mr. C. William Gabrielson '60
Mr. John W. Winings '60
Mr. Willard N. Nopper '61
Mr. James M. Webb '61
Mr. William A. Moy, PhD '65
Mr. Charles L. Fraust, MS '66, PhD '69
Mr. James A. Haney '66
Mr. Andrew J. Merutka '66
Mr. Alan T. Wetzel '66
Mr. Jerry F. Barnett '67
Dr. James G. Manegold '67
Mr. Charles M. Wingstrom '67
Mr. Mark Stephen Miller '74
Mr. Daniel Herbert Goetsch '76
Mr. Ronald A. Shafer '78
Mr. Charles A. Cornelius '84
Mr. Richard Jacob Haber, PhD '96
Mr. Ross E. Freeland '99
Mr. James Martin Sieleman '01

BIG IDEA



RESIZING THE VIRUS

Viruses are masters of delivery. When human beings become infected, viruses integrate with our cells and insert their genetic material inside our bodies. So, as researchers look for novel ways to deliver drugs more precisely, viruses seem like an obvious choice to help do the job.

"What we don't know is how the virus's properties, like size and shape, affect this delivery process," said Danielle Tullman-Ercek, associate professor of chemical and biological engineering.

A member of Northwestern's Center for Synthetic Biology, Tullman-Ercek has created a new method to help researchers discover just how much a virus's size matters. By mutating a single amino acid in a bacterial virus, her team drastically changed its size—shrinking it from 27 nanometers to 17 nanometers. Tullman-Ercek's collaborators plan to test the drug delivery performance of a smaller virus (visualized above) and compare it to that of a larger version of the same virus.

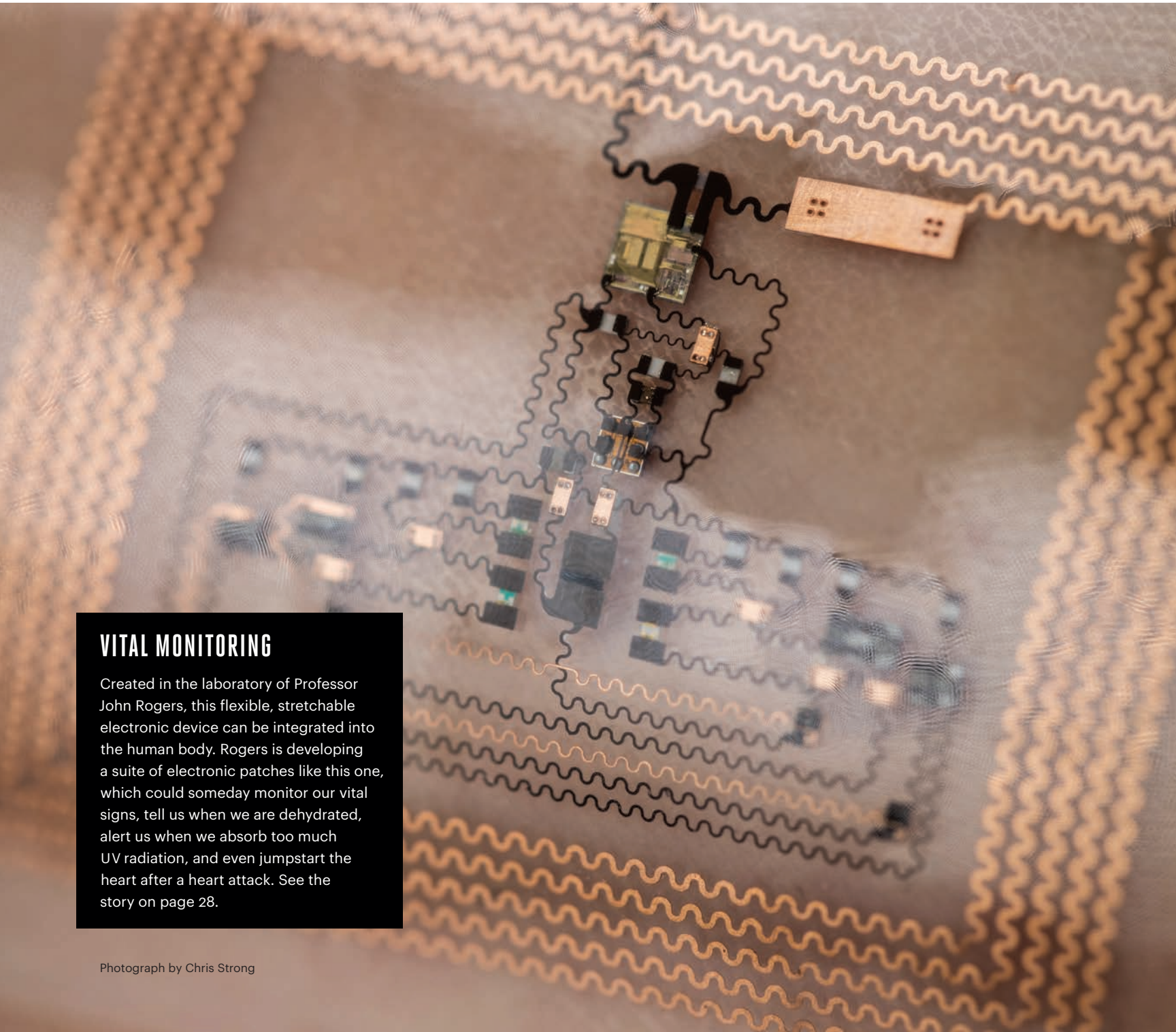
Northwestern | McCORMICK SCHOOL OF ENGINEERING

Robert R. McCormick School of
Engineering and Applied Science

Northwestern University

Technological Institute
2145 Sheridan Road
Evanston, Illinois 60208–3100

Nonprofit Organization
US Postage
PAID
Northwestern University



VITAL MONITORING

Created in the laboratory of Professor John Rogers, this flexible, stretchable electronic device can be integrated into the human body. Rogers is developing a suite of electronic patches like this one, which could someday monitor our vital signs, tell us when we are dehydrated, alert us when we absorb too much UV radiation, and even jumpstart the heart after a heart attack. See the story on page 28.

Photograph by Chris Strong