

# Spectrum

# REPAIR

PLUS

A VISION  
FOR HUMAN AND  
MACHINE  
INTELLIGENCE

P. 6



Tish Scolnik '10 and Mario Bollini '09, SM '12 first encountered the challenge of designing a better all-terrain wheelchair in a class led by Amos Winter SM '05 PhD '11. In their conversations with wheelchair riders worldwide, repairability was a recurring theme. Today, through GRIT, the start-up they cofounded with Winter—now Ratan N. Tata Career Development Associate Professor of Mechanical Engineering—they offer two products based on the same lever-drive system. The GRIT Freedom Chair is sold in the US; the Leveraged Freedom Chair is only available in developing countries. One key reason for the split: each is manufactured with (and can therefore be repaired with) the kind of off-the-shelf bike parts most commonly found in their respective parts of the world.

PHOTO: COURTESY OF GRIT

## Wide Angle

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### FRONT COVER

MIT Media Lab master's student Emily Salvador '16 designed and built these educational, musical train tracks as a project for a class called How to Make (Almost) Anything (see page 33).

PHOTO: KEN RICHARDSON

### BACK COVER

MIT Libraries staff use the Beaver Press in Barker Library. The press was constructed in the MIT Hobby Shop in spring 2016 by students in 21H.343/CC.120 Making Books in the Renaissance and Today. History professors Anne McCants and Jeffrey Ravel, who taught that course, now co-direct the press with technical director Ken Stone '72.

PHOTO: ERIC KEEZER

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## Spring 2018

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The Office of Resource Development gratefully acknowledges the leadership of the MIT Corporation in the MIT Campaign for a Better World.

## On a Quest for Knowledge

Since announcing the MIT Campaign for a Better World nearly two years ago, I have been on the road extensively telling anyone who will listen about the work our brilliant faculty, students, and alumni are doing to advance knowledge and to apply it whenever they see things that need fixing. From devices to diseases, systems to structures, the MIT community shares an irrepressible drive to design and implement remedies.

At last fall's Better World event in Boston, Regina Barzilay, MIT's Delta Electronics Professor of Electrical Engineering and Computer Science, told a wonderful crowd of more than 1,000 about an especially personal effort to engineer a better outcome. The winner of a MacArthur "genius grant" for her creative research at the intersection of machine learning and natural language processing, Professor Barzilay was diagnosed with breast cancer in 2014.

In the months that followed, she was shocked to learn that massive amounts of data about patients and the outcomes of their treatments are severely underutilized in oncology. Desperate for facts, she set out to find them, armed with her machine learning tools.

That night in Boston, Professor Barzilay shared her dream to leverage the extraordinary promise of machine intelligence to revolutionize cancer care—to mine a treasure trove of information to identify patterns and personalize treatment. In fact, that dream is already becoming reality: she and her research team recently deployed machine learning tools to several area hospitals. I believe the technology will prove similarly transformative across disciplines and throughout society.

It is with that broader inspiration that, this winter, we launched the MIT Intelligence Quest, an Institute-wide initiative on human and machine intelligence with two parts: The Core, which will advance the science and engineering of intelligence, and The Bridge, which will provide custom-built artificial intelligence tools to researchers in any discipline who do not see themselves as AI experts.

In effect, we aim to gain a deeper understanding of human and machine intelligence, as well as to give researchers who may not have Professor Barzilay's expertise in machine learning access to the same sophisticated toolbox.

Making a better world means repairing the one we have. By harnessing the potential of machine intelligence to attack intractable problems, the MIT Intelligence Quest offers exciting opportunities for impact.

Let the Quest begin.

L. RAFAEL REIF



(7)

LEARN MORE

[betterworld.mit.edu](http://betterworld.mit.edu)





**DANILO ROASCIO**

postdoc, MIT Space Systems Laboratory

“In certain conditions the sensors may not give a meaningful reading, or they may be fooled by specific characteristics of the world (such as mirror-like metal surfaces). If you have a second sensor, you may use it to compensate for the non-idealities of the main one. But this was not always possible, and the challenge becomes programming an algorithm that decides which measurements are real and which should be discarded.”

**BOUKE EDSKES '20**

undergraduate, mechanical engineering

“The coolest thing was definitely watching the team that broke the track record. That run was simply insane. Running all the cars on the course at once comes in a close second, though.”

**MILAD SIAMI**

postdoc, Institute for Data, Systems, and Society

“Before this IAP, my research was mainly focused on the theory of network optimization and control. Bridging the gap between theory and practice was the most challenging part of the course. Merging the theoretical knowledge and practical experiences of different group members helped us to complete the challenge.”

**HANNAH FIELD '19**

undergraduate, physics

**DIEGO LAZARES '18**

undergraduate, electrical engineering and computer science

COURSE LENGTH



1/10 mile



The converted 1/10-scale RC cars, a Lincoln Lab/AeroAstro collaboration, are equipped with LiDAR, stereo cameras, an inertial measurement unit, and embedded supercomputers. The hand-held controllers are used for a safety stop.

# Running the Course

MAX ALLEN '19

graduate student,  
electrical engineering  
and computer science

NANCY OUYANG '13

graduate student at Harvard University,  
computer science

"I was interested in the class because I want to learn everything that can bring my roboticist dreams to reality, and I wasn't as familiar with the algorithmic side of robotics (I did my undergrad in mechanical engineering at MIT, which is why I knew about IAP). To be able to go from nothing to having the car autonomously go around the course in just a few days—that was really inspiring."

AVERAGE SPEED OF FASTEST TEAM

## 10.1 mph

comparable to a full-scale vehicle hitting 101 mph on a mile-long course



WATCH THE CHASE

[spectrum.mit.edu/racecar](https://spectrum.mit.edu/racecar)

During MIT's Independent Activities Period (IAP), students get a break from their regular semester work to pick from a menu of lectures, workshops, and micro-courses. That's how roughly 20 students ended up sprinting through the basement of the Stata Center one January afternoon, trying to keep up with the miniature autonomous cars they'd programmed for maximum speed.

Titled 6.S184 RACECAR (Rapid Autonomous Complex-Environment Competing Ackermann-drive Robotics), the IAP class gathered for seven sessions. Between lectures, students met in teams, developing software with the algorithms they'd learned. The offering was spearheaded by MIT Lincoln Laboratory and MIT's AeroAstro and Electrical Engineering and Computer Science departments. It was taught this year for the fourth time by Lincoln Lab staff Michael Boulet SM '08 and Ken Gregson, along with Class of '48 Career Development Chair Associate Professor of Aeronautics and Astronautics Sertac Karaman SM '09, PhD '12. The director of Lincoln Lab Beaver Works, Robert Shin '77, SM '80, PhD '84, provided additional support and resources.

Karaman notes that the culminating race through Stata's hallways enlivens the class, but the main objective is broader: "to introduce our students to this hardware and have them develop algorithms and software that is similar to what is used in self-driving vehicles. We believe this experience transforms their understanding of the technology." The speed challenge does have a purpose beyond friendly competition, he adds: "It forces us to think outside the box, and work to develop software that utilizes the sensory and computational resources to their fullest, which is one of the biggest challenges in developing robots today."

This year one of the teams set a new speed record. "The handling of the turns and intersections was almost perfect, and I believe it was better than what a human driver can achieve with remote control," Karaman notes. "We had tremendous fun!"

PHOTO: KEN RICHARDSON

# A Fresh Look at the First Year

A design subject engages students as both stakeholders and problem solvers

TITLE

2.S991/CMS.S63

Designing the First Year at MIT

LECTURERS

- **Bruce Cameron SM '07, PhD '11**, director, System Architecture Lab
- **Bryan Moser '87, SM '89**, academic director and senior lecturer, System Design and Management program
- **Justin Reich**, assistant professor of comparative media studies; executive director, MIT Teaching Systems Lab
- **Glen Urban**, David Austin Professor in Marketing, Emeritus; MIT Sloan School of Management Dean, Emeritus
- **Maria Yang '91**, associate professor of mechanical engineering; faculty ambassador for MechE undergraduates

FIRST OFFERING

Spring 2018

ENROLLMENT

44 undergraduates  
10 graduate students



FROM THE CATALOG

This subject will explore the process of design while working on a specific challenge: the potential to significantly improve and innovate on the MIT undergraduate **first year**. Students will learn about the design process, ranging from the identification of needs and goals to developing concepts and modes of validation. Stakeholder needs identification will involve reaching out directly to the MIT community. Students will be responsible for project deliverables including a stakeholder needs assessment, analysis of integrated curricular and co-curricular changes in a tradespace of options, and final report and presentation. Students will also be exposed to principles of curriculum design and pedagogy as they develop a holistic perspective to the design of the MIT first year.

BACKGROUND

Although the first-year experience (FYE) at MIT can be fulfilling and energizing for some students, many others feel it needs significant improvement. A review of student, staff, faculty, and alumni views conducted in preparation for the class highlighted key areas for improvement, including more curricular flexibility and opportunities to explore different majors and careers, enhanced advising and mentoring, and greater emphasis on inspiring topics. Many students also voiced a desire for more personal support in making the **transition** from high school to the unique MIT culture. This class, which aims to address these challenges, was created by a team of some 30 **students**, staff, and faculty led by Vice Chancellor Ian Waitz (see sidebar).

SAMPLE LECTURES, READINGS, AND RESOURCES

- Week 9 lecture and assignment: Outcomes and Learning Dynamics in the First Year; Re-Framing the Solution Space: Decisions and Options
- Week 14 lecture and assignment: Leadership, Communication, and Preparing for Change; Reflections on Design
- FYE Data Book: current student demographics and pathways through MIT
- FYE Research Resources: online summary of findings on subjects ranging from the purpose of college to an examination of the first year at other universities

The last substantial change to the structure of the first year at MIT was in 1964.

Alexa Martin '19: "Everyone comes to MIT with different backgrounds, and everyone goes through different paths during their time here. Despite this I find it really interesting that many people still face the same issues and have the same needs."

Moser: "It's 'mens et manus,' learning by doing—what better way to solve this problem?"

# Vice Chancellor Ian Waitz on First-Year Design, the MIT Way

The first year is a critical time for students because it provides the foundation for the rest of MIT—and beyond. Concerns about the first year at MIT have been noted as far back as the report of the Lewis Committee in 1949 and have appeared in subsequent faculty reports over the decades. While changes have been made to some aspects, there has not been a holistic review of the first-year experience. When Ian Waitz, previously the dean of the School of Engineering, took on the newly created role of vice chancellor in 2017, he was tasked with engaging students and departments across MIT to create the most inspiring and effective educational atmosphere possible. Designing the First Year at MIT is one of those efforts; *Spectrum* asked Waitz to explain the thinking behind the creation of the class.

## Why does the first-year experience need to be redesigned?

**iw:** Each year we attract a stronger and stronger cohort of students to MIT. We dazzle our admits during Campus Preview Weekend with authentic problem-solving opportunities, only to have them spend much of their first year in traditional lecture-based courses with insufficient opportunity to explore majors and careers. Further, today's students, educational practices and technologies, and the world itself (new job sectors, the rapid pace of innovation, the global economy) are different from even a few years ago, so we need to keep up. Another way I think about it is: Do we offer the best first year on the planet? If not, then why not? And how can we get there?

## Why is this class a good format to address the problem?

**iw:** It's a very MIT way of tackling something—from the ground up, collaboratively, and with the kind of creativity and rigor that we expect of our students. Further, it is a very hard problem, and for MIT students, the harder the problem, the better. We have 50 brilliant young minds working 12 hours a week on how to improve the first year, with guidance from faculty and staff across all five schools. Including the students, the teaching staff, and mentors, we are employing greater than 700 people-hours per week. That is more than a typical faculty committee might do in an entire year. So we have some real gearing. Plus, it's a lot of fun working with the students.

## How does this class continue the tradition of student involvement at MIT?

**iw:** The class gives the students a stake in the education of future students. Most of the students in the class said the reason they signed up was they want to give back to MIT and make a great place even better. They are passionate about making a difference here, as they are in just about everything they do. Likewise, many of the alumni I have spoken to about this effort have said: How can I help? That's the MIT way.

## WORKSHOPS

The bulk of the problem-solving happens during weekly workshops. Teams of graduate and undergraduate students work with a **faculty mentor** to assess needs and create ideas. The course follows a typical “design spiral” to explore needs, generate concepts, identify key decisions, and validate options in an iterative fashion. This approach stimulates the students to observe the first year as a system, encouraging students to seek visionary and impactful changes **across stakeholders** (rather than minor improvements preconceived prior to framing the complex, interwoven set of challenges in the first year).

During the first spiral, each team will gather data on the needs of a different stakeholder group and develop concepts. During the second spiral, “teams of teams” will iterate on and synthesize the information and ideas generated during spiral one.

## OUTCOMES

By the end of the semester, the students will have decided on suggested changes to the first-year experience that will be presented to the MIT community, including student groups, the faculty, the Academic Council, and the MIT Corporation. Suggestions could be **curricular**, but could also include changes to the cocurricular and extra-curricular **aspects** of the first year.

—Stephanie McPherson SM '11

At a workshop several weeks into the subject, teams presented the data they had gathered thus far.

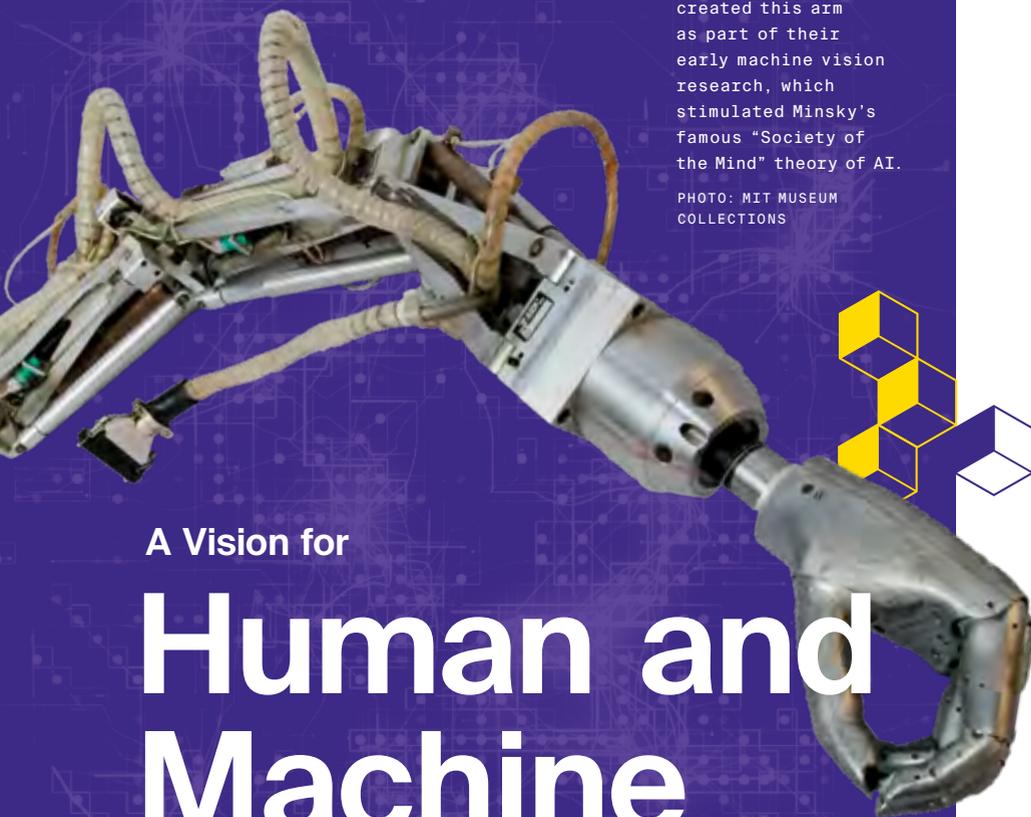
PHOTO: M. SCOTT BRAUER

Including the principal instructors, more than 30 faculty and senior staff mentors are participating, with representation from all 5 MIT schools.

Lead TA Ben Linville-Engler SM '18: “It's an opportunity for these groups to be a little bit more vulnerable around each other than they might be in a student-government-versus-MIT-administration type of situation.”

Linville-Engler: “Recommendations might be adjustments to existing things, such as recording GIRs as Pass/No Record, but I also think there could be some completely abstract, very different approaches.”

Martin: “People seem to care about soft skills, building character, having sufficient support and exploration, gaining confidence, and many other factors that can't be implemented by just adding more to the curriculum.”



In the 1960s, MIT professor Marvin Minsky and his group created this arm as part of their early machine vision research, which stimulated Minsky's famous "Society of the Mind" theory of AI.

PHOTO: MIT MUSEUM COLLECTIONS

A Vision for

# Human and Machine Intelligence

**How does human intelligence work, in engineering terms? And how can we use that deep grasp of human intelligence to build wiser and more useful machines?** This year MIT launched the MIT Intelligence Quest, an initiative to discover the foundations of human intelligence and drive the development of technological tools that can positively influence virtually every aspect of society. And to help ensure that the effects of these advances will, in fact, be positive, MIT researchers are leading a rigorous consideration of the social implications of these new technologies.

"A lot of historical evidence shows the process [of adjusting to transformative technologies] is a painful one... At the same time, we are capable technologically and socially of creating many new jobs that will take people to new horizons in terms of productivity and freedom from the hardest types of manual labor."

**Daron Acemoglu, Elizabeth and James Killian Professor of Economics (MIT News, February 1, 2018)**

"We have more than 200 investigators working directly on intelligence-related research areas. Student interest is tremendous. Our undergraduate and graduate classes in AI are oversubscribed. We have industry allies who share our passion for tackling big, real-world problems. And we have an entrepreneurial ecosystem that is unparalleled and that is ready to deliver the ideas that emerge from the MIT Intelligence Quest to the world."

**Anantha Chandrakasan, Dean of the School of Engineering; Vannevar Bush Professor of Electrical Engineering and Computer Science (MIT Intelligence Quest launch, March 1, 2018)**

"MIT's strengths in brain and cognitive sciences and computer science uniquely position us to lead the effort to understand intelligence, and our faculty and students believe the time is now."

**Michael Sipser, Dean of the School of Science and Donner Professor of Mathematics (MIT Intelligence Quest launch, March 1, 2018)**

## Automation and the Future of Work

In November 2017, MIT hosted a two-day conference titled "AI and the Future of Work." As David Autor, MIT's Ford Professor of Economics, noted during one session, a recent Pew Research Center survey indicates that Americans "are surprisingly aware, and worried, and rather negative" about the trajectory of the job market. "The public is broadly supportive of workplace automation being limited to dirty and dangerous jobs," Autor reported—even as most people "are positive about the impact that technology has had on their work."

Shortly after that conference, MIT launched a Task Force on the Work of the Future, which will conduct an empirical, interdisciplinary, and global study of how new developments in AI, automation, information technology, 3-D printing, and other areas of innovation are reshaping traditional jobs and the workplace.

The Institute-wide effort consists of 20-plus faculty and student members, as well as an external advisory board, and will draw upon the Institute's considerable existing expertise on this topic. Its leadership team includes Autor as well as David Mindell PhD '96, the Frances and David Dibner Professor of the History of Engineering and Manufacturing, and professor of aeronautics and astronautics; and Elisabeth Reynolds PhD '10, executive director of the MIT Industrial Performance Center and a lecturer in the Department of Urban Studies and Planning.



Panelists, from left, at the launch of the MIT Intelligence Quest: Megan Smith '86, SM '88, founder and CEO of shift7; Media Lab director Joi Ito; Dario Gil, vice president of AI and quantum computing at IBM; Daron Acemoglu, Elizabeth and James Killian Professor of Economics; and Melissa Nobles, Kenan Sahin Dean of SHASS.

PHOTO: GRETCHEN ERTL

## Familiar Problems, Cutting-Edge Context

At the March 1 symposium launching the MIT Intelligence Quest, a panel discussion explored the social implications of artificial intelligence, ranging from unequal access to technology and its benefits to the threats of surveillance and false news. Among the groups at MIT actively working to examine and address such issues are the School of Humanities, Arts, and Social Sciences (SHASS) and the MIT Media Lab. The leaders of those entities shared thoughts on why these concerns—though not as new as one might think—are newly urgent.

**Melissa Nobles, Kenan Sahin Dean of SHASS; professor of political science:** “What are the social, economic, political, artistic, ethical, and spiritual consequences of trying to make what happens in our minds happen in a machine? Who does this machine answer to? How do we ensure that the results of our efforts act as moral agents in society? Answering these questions responsibly means first backing up a little. What does it really mean to think? What is intelligence, anyway? Philosophers, social scientists, and artists have been grappling with these questions for centuries, but today these questions are being asked in a different context. We are on the verge of incorporating incredibly sophisticated tools for autonomy, prediction, analysis, and sensing into devices and environments that are as intimate to our daily experiences as our own clothing. These questions, in other words, are moving very rapidly out of a theoretical or speculative domain. They are headed directly into our lives and how we live them.”

**Joi Ito, director, MIT Media Lab:** “At the Media Lab we use the term ‘extended intelligence,’ rather than ‘artificial intelligence.’ Some of the problems of automation aren’t actually new. MIT mathematician Norbert Wiener in his book *The Human Use of Human Beings*, calls institutions ‘machines of flesh and blood.’ The idea is that any bureaucracy is a form of automation. If you look at the markets, they have certain evolutionary systems that cause injustices and harm, and we have trouble regulating and controlling them. So, I think there are some new problems, but there are also a lot of good, old-fashioned problems related to complex, self-adaptive systems that are evolving in an uncontrolled and harmful way. People like [environmental scientist] Donella Meadows and [MIT professor emeritus and inventor of system dynamics] Jay Forrester [SM '45] modeled these complex systems and were trying to suggest how we might intervene. There are some really interesting new problems, such as the reinforcing of biases by algorithms, but the fact is that these reinforced biases exist because of those old automated systems. And now we have booster rockets on those systems that make them even harder to control.”



RESEARCH SPOTLIGHT

### Algorithmic Justice

MIT Media Lab researcher **Joy Buolamwini SM '17** created the Gender Shades project ([www.gendershades.org](http://www.gendershades.org)) to examine error rates in the gender classification systems of three commercially available facial-analysis products. Her accompanying paper shows a significant accuracy gap between classifying male and female faces, as well as between darker and lighter faces. One gap was most pronounced: the highest error for light-skinned males was .08% while, for darker females, it was 34.7%—raising questions about the data sets used to train such machine learning systems. Buolamwini is founder of the Algorithmic Justice League, devoted to highlighting algorithmic bias and developing practices of accountability during the design, development, and deployment of coded systems.



PHOTO: BRYCE VICKMARK (BUOLAMWINI)

# The Core

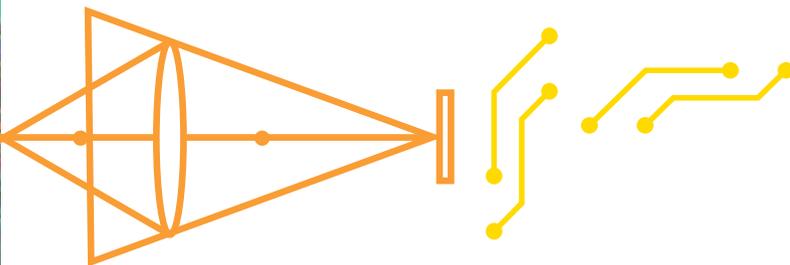
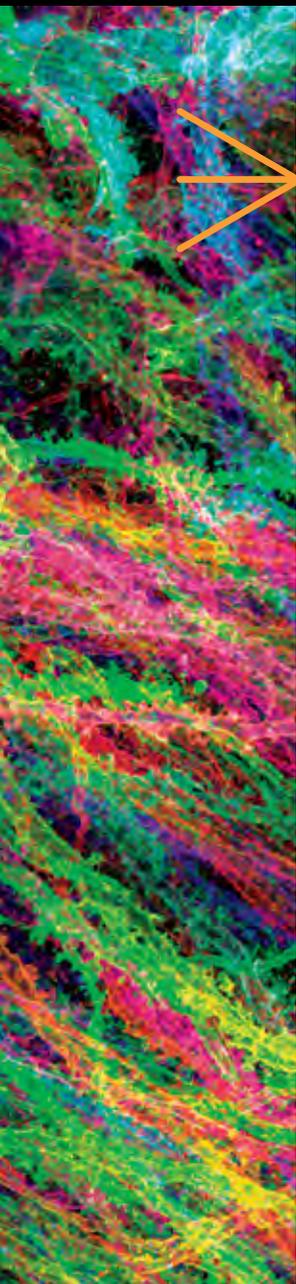
“The Core,” one of two linked entities comprising the Intelligence Quest, will advance the science and engineering of both human and machine intelligence. A key output of this work will be machine learning algorithms. At the same time, the Core seeks to advance our understanding of human intelligence by using insights from computer science.

On view through December 31 at the MIT Museum, *The Beautiful Brain: The Drawings of Santiago Ramón y Cajal* juxtaposes drawings by the founder of modern neuroscience with a collection of contemporary brain imagery, such as this one from a 3-D interactive visualization by researchers from the McGovern Institute for Brain Research and the MIT Media Lab’s Synthetic Neurobiology Group.

“There’s a list of great problems in science. The origin of the universe, the structure of time and matter, the origin of life. But here, we are after: What is intelligence? How does the brain create the mind? What is consciousness? That’s deeper than everything else, because after all it is with our mind that we try to solve all other problems.”  
**Tomaso Poggio, Eugene McDermott**  
**Professor of Brain and Cognitive Sciences; director, Center for Brains, Minds and Machines**

“For many years scientists and engineers have aspired to have a stronger connection between living systems and engineered machines. They have used living systems as inspiration for what might be possible in the future with machines. And by studying machines, they have aspired to create hypotheses and models that might explain the mysteries behind living systems.”  
**Daniela Rus, Andrew and Erna Viterbi**  
**Professor of Electrical Engineering and Computer Science; director of MIT’s Computer Science and Artificial Intelligence Laboratory (CSAIL)**

“This is a period that started with the rise of all of the fields we work in: cognitive science, neuroscience, artificial intelligence. And it’s only now that they’re mature enough that each one of them can start to deliver on its promises and they can talk to each other and really start to make progress together on the science and engineering of intelligence.”  
**Josh Tenenbaum PhD ’99, professor of computational cognitive science**



## Why the Focus on Human Intelligence?

In February 2018, Dean of the School of Engineering Anantha Chandrakasan, CSAIL director Daniela Rus, and James DiCarlo, the head of MIT's Department of Brain and Cognitive Sciences, participated in an "AMA" (ask me anything) session on Reddit. DiCarlo, the Peter de Florez (1938) Professor of Neuroscience, described his research goal in the AMA as follows: "to reverse engineer the brain mechanisms that underlie human visual intelligence, such as our ability to recognize objects on a desk, words on a page, or the faces of loved ones." He tackled several Reddit users' questions related to this goal, including the following:

**U/DOPU:** There's often great confidence (at MIT, particularly) placed on the idea that a better understanding of the brain and the mind that runs on it could very well lead to better computer algorithms and to general, strong AI. Two instances where this idea does seem to have had moderate success are perhaps reinforcement learning (somewhat inspired by VTA error-signaling neurons) and deep neural nets (somewhat inspired by [the] visual cortex). And yet so many other computational systems that exhibit astounding amounts of problem-solving capabilities seem to draw very little inspiration from nervous systems—Wolfram Alpha, for example, or Boston Dynamics' robots, or a lot of the expert

systems AI work done a few decades ago. What is the argument for going about attempting to figure out human intelligence such that we can use it on machines, besides the couple [of] examples I listed above? Wouldn't it perhaps be easier to just focus on building general AI? In other words, why the focus on human intelligence?

**DICARLO:** Great question! You correctly point out that not all areas of progress in AI-related systems have been driven by detailed knowledge of the brain and the mind (although many of these are at least brain-inspired).

So one way to phrase your question is this: what is the most efficient path to discover human-level AI? Path 1: Have engineers work on their own to see how far they can get. Path 2: Have engineers work with guidance from the brain and the mind. No one knows the answer to the question of which path is faster.

However, the recent successes (esp[ecially] reinforcement learning and deep CNNs [convolutional neural networks]/deep learning) have shown that Path 2 can deliver a very impressive return. The human brain has had millions of years to develop its capabilities—while our engineers could probably work faster than evolution, it might take many many years to find processing strategies that work as well as the brain in some aspects of intelligence. Thus, Path 1 may be very, very long. So why not take a huge shortcut and look to the brain and the mind (Path 2)?

Also note that the above considerations are only about the question of paths to AI. But Path 2 has additional human benefits to it as well. An engineering description of

the brain will not only allow us to build better machines. It will also allow us see new ways to repair, educate, and perhaps even augment our own minds!



READ THE FULL AMA  
[redd.it/7ur4iz](http://redd.it/7ur4iz)



RESEARCH SPOTLIGHT

## Research by Webcam

How do children learn so much from so little, so quickly? Professor of cognitive science **Laura Schulz** investigates that profound question in the Early Childhood Cognition Lab. Her group's research can now benefit from a larger, diversified stream of data thanks to Lookit, an online laboratory platform conceived and run by research scientist **Kim Scott PhD '18** (pictured, right, with Schulz). Via webcam, the researchers record babies' reactions and attention to onscreen phenomena. Parents can participate from their own homes at their convenience, dramatically widening the demographics and volume of participants the researchers are able to recruit for a given study.



RESEARCH SPOTLIGHT

## Predicting Sound from Video

In the Laboratory for Computational Audition, **Joshua McDermott PhD '07** operates at the intersection of psychology, neuroscience, and engineering. An assistant professor in the Department of Brain and Cognitive Sciences, McDermott and his team work to understand how humans derive information from sound, to improve treatments for hearing impairment, and to enable the design of machine systems that mirror human abilities to recognize and interpret sound. In one such project, McDermott collaborated with colleagues from CSAIL on an algorithm that can learn how to predict sound from video footage and produce the expected sound realistically. Such an algorithm could strengthen machines' ability to understand the physical properties of objects.

# The Bridge

MIT has more than 200 principal investigators whose research bears directly on intelligence—and countless more whose own work could benefit from that research. The second of the Intelligence Quest’s linked entities, “The Bridge,” will be dedicated to the application of MIT discoveries in natural and artificial intelligence to all disciplines. The Bridge will provide a variety of assets to the MIT community, including intelligence technologies, platforms, and infrastructure; education for students, faculty, and staff about AI tools; rich and unique data sets; technical support; and specialized hardware.



The MIT Intelligence Quest launch event ended with a student poster session that included projects focused on robotics; physics, engineering, and security; and vision and language.

PHOTO: GRETCHEN ERTL

## More than the Sum

Cross-disciplinary projects powered by AI, such as these already underway at MIT, have far-reaching applications

### THE SUSTAINABLE MATERIALS ENGINEER

**Elsa Olivetti PhD '07**, Atlantic Richfield Assistant Professor of Energy Studies in the Department of Materials Science and Engineering

### THE ALGORITHM SPECIALIST

**Stefanie Jegelka**, X-Consortium Career Development Assistant Professor of Electrical Engineering and Computer Science

Olivetti and Jegelka are joining forces to create a neural network that can pore through scientific papers and, through pattern recognition, extract “recipes” for producing particular types of materials. In a recent paper, Olivetti, Jegelka, and colleagues used this mechanism to suggest alternative recipes for known materials. Their work could also help to identify practical ways to create new materials with desirable properties.

### THE FINANCIAL ECONOMIST

**Andrew Lo**, Charles E. and Susan T. Harris Professor at the MIT Sloan School of Management

### THE CRYPTOGRAPHER

**Vinod Vaikuntanathan SM '05, PhD '09**, associate professor of electrical engineering and computer science

Lo and Vaikuntanathan are teaming up to measure the economic effects of cyberattacks. Together they are creating a multi-party platform to collect data that will give markets and firms better cybersecurity risk information, while respecting privacy concerns. Their initial efforts will be focused on helping financial institutions to share intrusion data using secure multiparty computation techniques, and they’ve already signed up several companies for a pilot project.

### THE OCEAN ENGINEERS

**Genevieve Flaspohler**, PhD student, MIT/Woods Hole Oceanographic Institute (WHOI) Joint Program; and **Yogesh Girdhar**, WHOI assistant scientist

### THE ROBOTICIST

**Nicholas Roy**, professor of aeronautics and astronautics and director of the Robust Robotics Group, CSAIL

Flaspohler and her co-advisors Girdhar and Roy are collaborating on the development of unsupervised or minimally supervised machine learning algorithms for autonomous underwater vehicles (AUVs). Together, they are honing the capability of AUVs to explore unknown marine environments that are inaccessible to human divers, while endowing them with the semantic understanding to interpret the images and other environmental sensor data they collect.



# Intelligent Health

One of the most fertile areas for AI technologies is in medicine and wellness

## APPLYING ANALYTICS

Health care analytics are a passion for **Dimitris Bertsimas SM '87, PhD '88**, the Boeing Leaders for Global Operations Professor at the MIT Sloan School of Management and co-director of MIT's Operations Research Center. His group has developed a system called LiA (Lifestyle Analytics) that guides personalized diabetes management by eliciting patient preferences, modeling blood glucose behavior and updating these models to match individual measurements, and generating a customized diet and exercise plan. Among Bertsimas's many other projects are systems for the analysis and design of clinical trials for cancer drug combinations; health plan selection that weighs the needs of both employer and employees; and decision support for surgeons selecting donor kidneys for their patients.

## PERSONAL ROBOTS

Social robotics pioneer **Cynthia Breazeal SM '93, ScD '00** is associate professor of media arts and sciences, leads the Personal Robots Group at the MIT Media Lab, and is founder and chief experience officer of Jibo, Inc., maker of the world's first "family robot." Her research focuses on developing the principles, techniques, and technologies for personal robots that are socially and emotionally intelligent, interact and communicate with people in human-centric terms, and collaborate with people as helpful teammates and companions. Her recent work investigates the potential of social robots to help people of all ages achieve personal goals that contribute to quality of life in domains such as education, creativity, health care, well-being, and aging in place.

## SYNTHETIC BIOLOGY

Reprogramming bacteria to detect and treat infectious disease is one of the great frontiers of synthetic biology. One of that field's founders, **James J. Collins**—MIT's Termeer Professor of Medical Engineering and Science and a member of the Broad Institute—designs and creates synthetic gene networks for a variety of

biotechnology and medical applications. Collins and his team use network biology approaches to study antibiotic action, bacterial defense mechanisms, and the emergence of antibiotic resistance. According to Collins, AI is the key to fast-tracking such efforts, even as synthetic biology offers a new, living platform for the development of AI.

## NONINVASIVE MONITORING

**Dina Katabi SM '99, PhD '03** is the Andrew and Erna Viterbi Professor of Electrical Engineering and Computer Science at MIT, leader of the NETMIT research group at CSAIL, and director of the MIT Center for Wireless Networks and Machine Computing. Katabi combines novel sensing technologies with machine learning, optimization theory, and signal processing algorithms to solve real-world problems. One of these problems—inspired by Katabi's own family experiences—is the noninvasive in-home monitoring of the elderly. She and her team have developed a device that uses low-power wireless signals, like WiFi, to track human motion, which among other health applications can generate an alert if an occupant falls or appears likely to fall.



Above: Leila Pirhaji PhD '16 spoke at the Intelligence Quest launch about her startup, ReviveMed, which uses AI technology developed at MIT to leverage data from metabolomics (the study of small molecules) to expedite drug discovery. Pirhaji created the company with support from MIT programs including delta v, iTeams, StartMIT, StartIAP, the \$100K Entrepreneurship Competition, and the Sandbox Innovation Fund.

PHOTO: GRETCHEN ERTL

## SINGLE-CELL GENOMICS

Computational and systems biologist **Aviv Regev**—MIT biology professor; Broad Institute core member and chair of faculty; Howard Hughes Medical Institute Investigator; and cofounder of the Human Cell Atlas initiative—studies how complex molecular circuits function in cells and between cells in tissues. The Regev lab invents experimental methods and associated computational algorithms, motivated by machine learning, that allow inference even in the context of the vast space of biological possibilities. Her lab has pioneered foundational experimental and computational methods in single-cell genomics, working toward greater understanding of the function of cells and tissues in health and disease, including autoimmune disease, inflammation, and cancer.



# Forging Connections

To power the MIT Intelligence Quest, the Institute will raise financial support through corporate sponsorship and philanthropic giving. An essential element of the new initiative is forging connections with innovative companies and individuals who share MIT's passion for work in intelligence—building on the model that was established in September 2017 with the announcement of the MIT-IBM Watson AI Lab.

## Teaching Machines to Recognize Actions

### An update from the MIT-IBM Watson AI Lab

A person watching videos that show things opening—a door, a book, curtains, a blooming flower, a yawning dog—easily understands that the same type of action is depicted in each clip. “Computer models fail miserably to identify these things. How do humans do it so effortlessly?” asks Dan Gutfreund, a principal investigator at the MIT-IBM Watson AI Laboratory and a staff member at IBM Research. “We process information as it happens in space and time. How can we teach computer models to do that?”

Such are the big questions behind one of the new projects underway at the MIT-IBM Watson AI Laboratory, a collaboration for research on the frontiers of artificial intelligence. Launched last fall, the lab connects MIT and IBM researchers to work together on AI algorithms, the application of AI to industries, the physics of AI, and ways to use AI to advance shared prosperity.

The Moments in Time data set is one of three new projects funded by the lab. It pairs Gutfreund with Aude Oliva, a principal research scientist at the MIT Computer Science and Artificial Intelligence Laboratory, as the project's principal investigators. Moments in Time is built on a collection of 1 million annotated videos of dynamic events unfolding within three seconds. Gutfreund and Oliva, who is also the MIT executive director at the MIT-IBM Watson AI Lab, are using these clips to address one of the next big steps for AI: teaching machines to recognize actions.

“As we grow up, we look around, we see people and objects moving, we hear sounds that people and objects make. We have a lot of visual and auditory experiences. An AI system needs to learn the same way and be fed with videos and dynamic information,” Oliva says. For every action category in the data set, such as cooking, running, or opening, there are more than 2,000 videos. The short clips enable computer models to better learn the diversity of meaning around specific actions and events. “This data set can serve as a new challenge to develop AI models that scale to the level of complexity and abstract reasoning that a human processes on a daily basis,” Oliva adds. Oliva and Gutfreund, along with additional researchers from MIT and IBM, met weekly for more than a year to tackle technical issues, such as how to

choose the action categories for annotations, where to find the videos, and how to put together a wide array so the AI system learns without bias. The team also developed machine learning models, which were then used to scale the data collection.

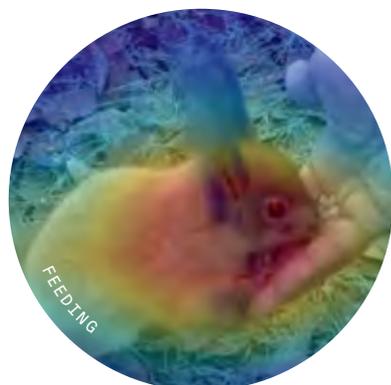
One key goal at the lab is the development of AI systems that move beyond specialized tasks to tackle more complex problems and benefit from robust and continuous learning. “We are seeking new algorithms that not only leverage big data when available—but also learn from limited data to augment human intelligence,” said Sophie V. Vandebroek, chief operating officer of IBM Research, about the collaboration.

In addition to pairing the unique technical and scientific strengths of each organization, IBM is also bringing MIT researchers an influx of resources, signaled by its \$240 million investment in AI efforts over the next 10 years, dedicated to the MIT-IBM Watson AI Lab. And the alignment of MIT-IBM interest in AI is proving beneficial, according to Oliva.

“IBM came to MIT with an interest in developing new ideas for an artificial intelligence system based on vision. I proposed a project where we build data sets to feed the model about the world. It had not been done before at this level. It was a novel undertaking. Now people can go to our website and download the data set and our deep-learning computer models.”

In addition, Oliva says, MIT and IBM researchers have published an article describing the performance of neural network models trained on the data set, which itself was deepened by shared viewpoints. “IBM researchers gave us ideas to add action categories to have more richness in areas like health care and sports. They broadened our view. They gave us ideas about how AI can make an impact from the perspective of business and the needs of the world,” she says. —Meg Murphy

Screenshots from the Moments in Time data set.



# David Siegel on MIT's "Challenging and Collaborative Culture"

Computer scientist, entrepreneur, and philanthropist David Siegel SM '86, PhD '91 is a founding advisor of the MIT Intelligence Quest and an early thought partner in its formation. He is also a member of the MIT Corporation, cofounded the Scratch Foundation with the MIT Media Lab's Mitchel Resnick SM '88, PhD '92, and has served on the external advisory committee of the Center for Brains, Minds and Machines since its inception. In his remarks at the Intelligence Quest launch, Siegel described the innovative MIT spirit he first observed as a doctoral candidate at the Artificial Intelligence Lab, and which inspired his cofounding of Two Sigma Investments, where he currently serves as cochairman:

"I arrived at the AI Lab here at 545 Tech Square in 1983. I was lucky enough to work in the presence of pioneers like Marvin Minsky and Patrick Winston. [...] What inspired me the most was the innovation happening in that building. It was the challenging and collaborative culture. It was the wellspring of scientific progress. I saw that a small group of unconventional thinkers, given the right environment, the right culture, could ultimately help to transform the world.

"Years later, I would use Tech Square's culture as a model for the company I cofounded, Two Sigma. Tech Square taught me an awful lot about innovation. To innovate, you cannot have an overly constrained environment. You can't put time limits on the problem because that implies you already know the answer. [...] Finally, you can't make progress in isolation. You need to be around talented people who will tell you what you're doing wrong, who will push you to think differently, and people who have diverse skills. That was and still is and always will be the MIT way.

"The atmosphere at Tech Square was truly entrepreneurial. That was the vision that brought me to MIT in the first place. And this is the vision MIT is building on and expanding with its Intelligence Quest."

# Eric Schmidt Provides Support to MIT Intelligence Quest

Eric Schmidt, Alphabet Technical Advisor and former Executive Chairman and CEO of Google, and his wife, Wendy, have pledged to help fund the new MIT Intelligence Quest. The Schmidts' unrestricted gift will support the critical and evolving needs of the initiative. Conversations at MIT regarding human and machine intelligence inspired Eric and Wendy's gift. MIT President L. Rafael Reif announced in February that Schmidt will join MIT as a Visiting Innovation Fellow for one year, starting in spring 2018. "Eric's brilliant thought leadership has been crucial to the development of the MIT Intelligence Quest," says Reif. "He recognized that MIT would play an important role in advancing human and machine intelligence, and we have benefited enormously from his time, wisdom, and financial support during a pivotal moment in this emerging and critical field of study."

"MIT has a uniquely powerful resource to turn Cambridge into a true center for AI: the talent and passion of your students."

**Eric Schmidt, founding advisor,  
MIT Intelligence Quest advisory board  
(MIT Intelligence Quest launch, March 1, 2018)**



At the Intelligence Quest launch, Alex Amouyel, executive director of MIT's Solve initiative, announced the 2018 Solve Global Challenges—the tackling of which may harness AI talent from people within and outside MIT. Innovators worldwide are invited to submit solutions in the new challenge areas: coastal communities, work of the future, teachers and educators, and frontlines of health.

PHOTO: GRETCHEN ERTL

# The MIT-SenseTime Alliance on Artificial Intelligence

In February, AI leader SenseTime became the first company to join the MIT Intelligence Quest following its launch. SenseTime was founded by MIT alumnus Xiaou Tang PhD '96 and specializes in computer vision and deep learning technologies. The MIT-SenseTime Alliance on Artificial Intelligence aims to open up new avenues of discovery across MIT in areas such as computer vision, human-intelligence-inspired algorithms, medical imaging, and robotics; drive technological breakthroughs in AI that have the potential to confront some of the world's greatest challenges; and empower MIT faculty and students to pursue interdisciplinary projects at the vanguard of intelligence research.

Tang conducted his PhD research in underwater robotics and computer vision at the Institute, applying computer vision to the study and classification of underwater imagery. "As an MIT alumnus, I'm grateful to have this opportunity to collaborate with my alma mater, especially on something that is dear to my heart—to advance research on artificial intelligence," says Tang, who is also a professor of information engineering at the Chinese University of Hong Kong. "SenseTime is committed to innovating in the fields of computer vision and deep learning. With the creation of the MIT-SenseTime Alliance on Artificial Intelligence, I'm confident that we will bring together the world's best and brightest talent to further advance the state of the art for AI to the benefit of society."



REPAIR



The first step in repairing something is to understand how it works. Many of the people who find their way to MIT discovered an impulse for fixing things early in life, spending solitary hours dismantling and reassembling household objects with curiosity, persistence, and a few old tools.

To undertake repairs to the most complex things, however—systems, situations, societies—takes the collaboration of many open minds and steady hands. It may require new tools and processes yet to be invented, or the ability to step back and see the world through other people’s eyes. MIT’s problem solvers are called to figure out how things work, yes, but also to imagine how they could work. They are driven not just to fix what’s broken, but to make things better.

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In an Independent Activities Period workshop at the Center for Materials Science and Engineering X-ray Facility, participants (including graduate student Stephen Filippone, pictured) salvaged outdated X-ray equipment. There was a twist: rather than restoring the components for their original purpose, they redesigned them for use in new X-ray spectroscopy instrumentation to support the study of energy materials.

PHOTO: KEN RICHARDSON

# To the Letter

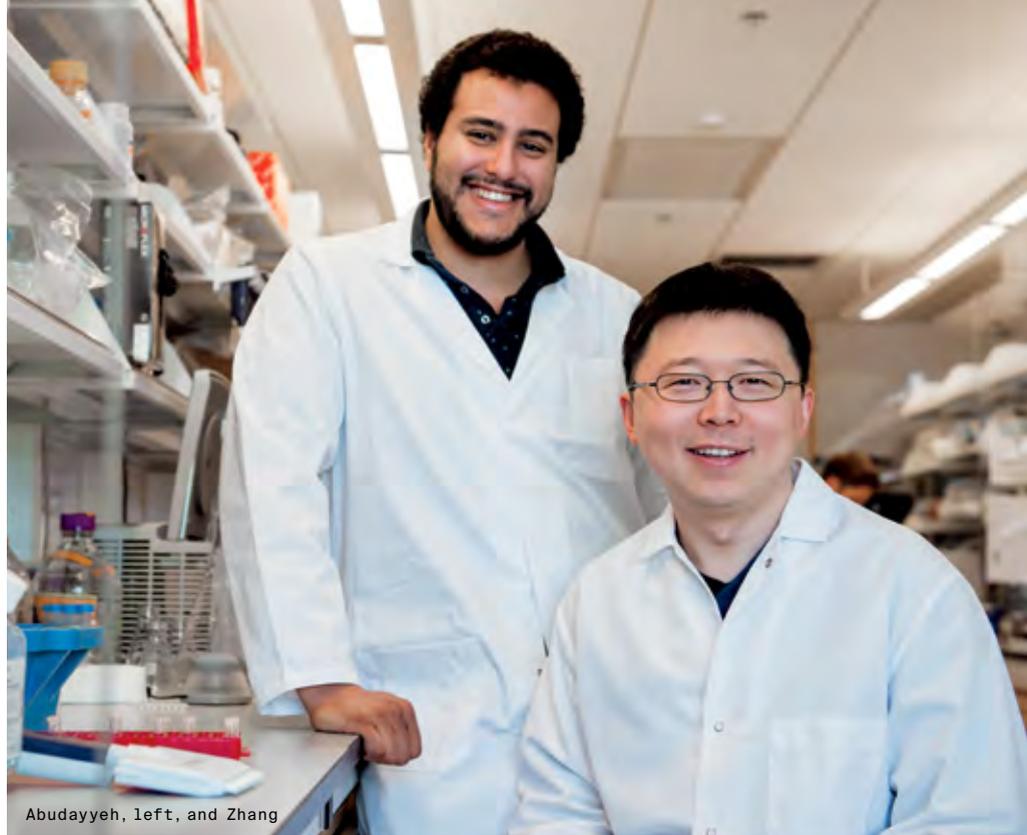
**In the Zhang lab, a leap forward in CRISPR-based genome editing offers precision RNA fixes with major therapeutic implications**

In Feng Zhang's laboratory at MIT's McGovern Institute for Brain Research and the Broad Institute, members "share a sense of excitement and urgency," says Omar Abudayyeh '12, a sixth-year MD/PhD student in the Harvard-MIT Program in Health Sciences and Technology. That's because they are propelled by a common purpose: expanding the toolkit for manipulating genes in eukaryotic cells, and engineering genes in order to understand, treat, and cure some of our most intractable diseases and disorders.

"What Feng instills in us is the desire to do science at the edge, to push the needle," says Abudayyeh.

The group's most recent research accomplishes just that. They have devised a gene editing tool called REPAIR that can make precision fixes in human RNA. "It's exciting because there are thousands of diseases caused by genetic mutations," says Abudayyeh, who is co-first author, along with fellow graduate students Jonathan Gootenberg '13 and David Cox, of an October 25, 2017, article in *Science* describing this work. "REPAIR revolutionizes how we can do genome editing, and makes it possible to correct problems, even down to a single letter of genetic information."

The acronym stands for "RNA Editing for Programmable A to I Replacement"—referring to the tool's ability to change a single RNA letter, or nucleic acid base, to another. A is adenosine, and I is inosine (which cells read as G, or guanosine). Single-letter mutations from G to A—the kind REPAIR targets—have been identified in such devastating human diseases as Duchenne muscular dystrophy and Parkinson's.



Abudayyeh, left, and Zhang

This work springboards from prior discoveries by Zhang, the Patricia and James Poitras (1963) Professor in Neuroscience at the McGovern Institute, a core institute member of the Broad Institute, and an associate professor in the departments of brain and cognitive sciences and biological engineering. Since opening his lab at MIT and Broad in January 2011, the 36-year-old Zhang has been pioneering the development of CRISPR genome editing tools, technologies based on naturally occurring enzymes derived from bacterial immune systems, which can precisely snip the DNA of mammalian cells.

## New domains of medical treatment

In the long slog to make personalized medicine a reality, CRISPR technology represents a potential superhighway. CRISPR systems have made it possible both to diagnose infections and diseases in people with incredible speed, and to inactivate genes associated with many diseases. With REPAIR, CRISPR-based

Spotlight on Professorships

## Doing More for Mental Health

In 2017, Feng Zhang became the inaugural chairholder of MIT's Patricia and James Poitras (1963) Professorship in Neuroscience. This new endowed professorship was made possible through a generous gift by James '63 and Patricia Poitras that extended their longtime support for mental health research.

According to Zhang, the endowed chair "helps me advance developments in bioengineering, and gives me the ability to also target some technologies for treating brain-related diseases. The professorship and interactions I have with other members of the Poitras Center for Affective Disorders Research"—established by the Poitrases at MIT's McGovern Institute in 2007—"together support more innovative and risk-taking research. It helps us do more."

genetic engineering takes another leap forward. Says Zhang, “The REPAIR system brings all the machinery necessary to generate changes at the RNA level into a cell, fixing genetic sequences and producing the correct proteins.”

It’s a tool that lifts a burden for biomedical researchers. “REPAIR eliminates problems that have inhibited therapeutic possibilities until now,” explains Abudayyeh. “When you edit DNA to make a correction, you worry that if the edit goes off target, it might create a mutation that accidentally turns a gene on, a mistake that gets replicated in the genome, potentially making cells cancerous.”

But because RNA itself doesn’t naturally replicate, cells subject to REPAIR’s RNA fixes don’t pass on changes to the next generation of cells, and engineered genes can revert to their original form. “We have a technology that’s like a small molecule drug: when it’s taken, it has an effect, and when you stop taking it, the effects stop,” says Abudayyeh.

This technology breaks open new domains of medical treatment. Certain kinds of liver diseases and anemias, unyielding to current therapies, are likely susceptible to REPAIR. “And it will be great for illnesses that are temporal,” says Abudayyeh. “Imagine taking something to alleviate a migraine flare, or defend against an RNA-based virus infection, like influenza.”

The technology also offers new possibilities for disorders of the brain, which Zhang has long sought to address. “During college, I had a close friend who suffered from a psychiatric disease, and from that point on, I became determined to help such patients,” he says. REPAIR provides hope, because unlike with previous CRISPR technology, says Zhang, “We now have an opportunity to make precise therapeutic corrections in neurons.”

For certain types of mental illness and other disorders and diseases that have been associated with specific, inherited mutations—think autism and Alzheimer’s and Huntington’s—novel therapies can’t come fast enough. “I get emails from patients who are affected by certain diseases,” says Zhang. “It makes me very motivated to work on these problems.”

### Pushing discovery forward

“REPAIR is a broad platform with applications for many diseases, and in order to realize its full potential, we’d like to see as many different researchers as possible explore and apply the technology,” says Zhang. “We make progress when technology is open and many groups adopt these tools.”

So Zhang is sharing the REPAIR system, as well as earlier CRISPR tools, through the genetic material repository, Addgene. More than 2,300 labs in 62 countries have taken advantage of the lab’s free resources.

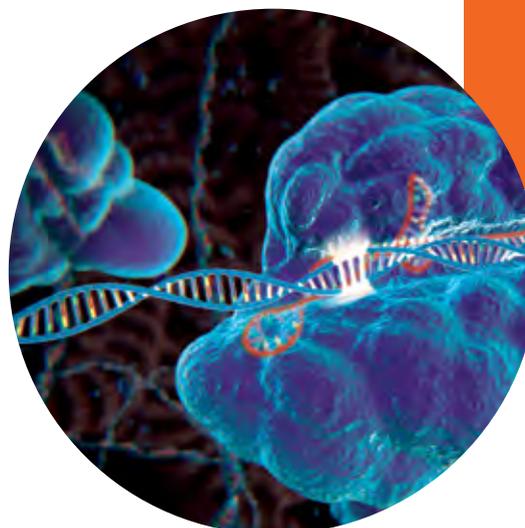
While seeding medical research laboratories around the world with the products of their work, Zhang and his industrious team continue to refine current gene editing tools and seek fresh RNA-based applications. Their next hurdle: determining the best ways to deliver the REPAIR system into the human body.

“For both genome editing and gene therapy in general, we are trying to figure out how to get our tools into the right organs and tissues,” says Zhang. “It’s especially difficult to get payloads into the brain,” adds Abudayyeh. “We need new kinds of molecular biology to enable delivery vectors for difficult tissues.”

Team members rarely lose sight of the need for their work, or the challenges ahead. “Our lab feels like a startup,” says Abudayyeh. “I have never been in a place with such energy, or such a density of talented people.”

Today, Abudayyeh is teasing out new enzymes from bacteria and finding ways to engineer genetic systems that he hopes will soon make an impact on human health. And while participating in this biotechnology revolution can be exhausting, says Abudayyeh, “doing science at the edge is exhilarating.”

—Leda Zimmerman



Spotlight on Fellowships

## The Gift of Intellectual Freedom

Among the honors and fellowships that have fueled Omar Abudayyeh’s graduate education and research is the 2015 Friends of the McGovern Institute Fellowship. The fellowship represents the collective power of numerous MIT supporters to champion the potential of a promising scientist.

Explains Abudayyeh, “When I received my Friends of the McGovern Institute Fellowship, I was working on methods for applying CRISPR technology to target sequences of RNA. Because the fellowship covered my tuition and stipend, I had the freedom in the lab to explore different types of experiments, and maybe tackle bigger questions than I normally would. It gave me intellectual freedom, because I didn’t have to think about my budget all the time.”

An artist’s depiction of the CRISPR-Cas9 method for genome editing.

IMAGE: MCGOVERN INSTITUTE

# To Your Health

From head to toe, MIT researchers are finding remedies for what ails us

## EYES



Typical treatments for eye diseases such as glaucoma rely on topical drops that, even with proper use, cannot penetrate deeply. LayerBio, a startup focused on ophthalmology and wound care, offers an alternative based on nanotechnology invented by **PAULA HAMMOND '84, PHD '93**, David H. Koch Professor in Engineering and head of the Department of Chemical Engineering. With support from MIT's Deshpande Center for Technological Innovation, Hammond and team developed a coating, composed of ultrathin layers of molecules of alternating charge, for sustained release of drugs to a targeted area.

## EARS



A therapy for sensorineural hearing loss could be on the horizon from Frequency Therapeutics, founded on regenerative biology research by MIT Institute Professor **ROBERT LANGER SCD '74** and former Langer Lab postdoc **JEFFREY KARP**, whose affiliations include Harvard, Brigham and Women's Hospital, and the Broad Institute, and who teaches in the Harvard-MIT Health Sciences and Technology Program. Under CEO **DAVID LUCCHINO MBA '06** and chief scientific officer **CHRIS LOOSE PHD '07**, Frequency has successfully completed a first-in-human safety study of a small-molecule drug intended to activate the regrowth of sensory cells in the inner ear.

## SPINE



Could bioelectronics restore movement to those paralyzed by spinal cord injury? **POLINA ANIKEEVA PHD '09**, Class of 1942 Associate Professor in Materials Science and Engineering and associate director of the Research Laboratory of Electronics, is designing tiny polymer fibers with embedded electrodes that could be implanted alongside damaged neurons and bypass the injury to transmit electrical signals—or act as scaffolds to support new nerve tissue as it grows. Her group's work could have implications not only for paraplegia but for conditions ranging from Parkinson's to depression.

## HEART



Failing hearts could someday get an assist from a soft robot designed by mechanical engineering faculty member **ELLEN ROCHE**, Hermann von Helmholtz Career Development Associate Professor at MIT's Institute for Medical Engineering and Science. Her device—essentially a heart-hugging silicone sleeve that mimics the material properties and movement of the heart and assists with pumping without contacting blood—was created in collaboration with Harvard researchers and Boston Children's Hospital surgeons, and was demonstrated in 2017 to effectively restore heart function in pigs.



## GUT

Cancer, diabetes, autism, inflammatory bowel disease (IBD)—these and many other medical conditions have been linked to the delicate ecosystem of microbes in the gastrointestinal tract. The Center for Microbiome Informatics and Therapeutics, founded in 2015 by MIT biological engineering professor **ERIC ALM** and Massachusetts General Hospital and the Broad Institute's **RAMNIK XAVIER**, is already making strides toward noninvasive diagnostics and personalized treatments for IBD. Long term, the center will focus its scientific and machine learning expertise—along with its growing “library” of global bacteria and network of clinical partners—on addressing a wide range of microbiome-associated diseases.

## TISSUE



After surgery, leakage from sutures can be life-threatening. At MIT's Institute for Medical Engineering and Science, principal research scientist **NATALIE ARTZI** and **ELAZER EDELMAN '78, SM '79, PHD '84**, Thomas D. and Virginia W. Cabot Professor of Health Sciences and Technology, are designing an adhesive material that can be optimized to thrive in different tissue microenvironments.

Having demonstrated that the sealant's effectiveness depends on the disease state of tissue, the researchers—both also affiliated with Harvard Medical School and Brigham and Women's Hospital—are at work on a formulation that titrates itself to the tissue, to provide a personalized solution for each patient.

## CELLS



Most cancer cells have too many or too few chromosomes. When this imbalance—called aneuploidy—occurs during the division of healthy cells, the immune system calls in special cells to eliminate the aberration.

**ANGELIKA AMON**, Kathleen and Curtis Marble Professor in Cancer Research in MIT's Department of Biology and a member of the Koch Institute for Integrative Cancer Research, leads a team that has identified and is working to understand this built-in repair mechanism. Among the mysteries: why doesn't this process control the growth of cancer cells as with healthy cells?

The answer could point to new therapies for virtually all types of cancer.



## LEGS

When someone whose leg has been amputated is fitted for a prosthesis, even minor mismatches between limb and device can damage skin and soft tissues. Each socket's design must be highly personalized through what is currently an “artisanal process” requiring extensive time and money, says **KEVIN MOERMAN**, the research scientist leading the computational biomechanics research track at the MIT Media Lab's Biomechatronics group. Moerman and colleagues are developing an automated, fully data-driven process for prosthetic socket design and production that can deliver a precise fit.

# Shore Lines

The Nepf lab is helping to restore wetlands by modeling how and why they are so beneficial

In October 2012, Hurricane Sandy slammed into the Eastern Seaboard with powerful winds and a storm surge cresting up to 13 feet. Scores of people died. Thousands of homes were lost. And it would have been even worse without the wetlands hugging the coastline. Marshlands prevented an additional \$625 million of property damage, one study found. But more than half the wetlands in the United States have disappeared in the last half century, denuding many miles of coastline and rendering seaside land vulnerable to storms in the future. (The same goes for countries all over the world—wetland loss is widespread.) A big culprit, says Judy Qingjun Yang SM '15, a graduate

student in the Department of Civil and Environmental Engineering at MIT, is erosion of the soils and sands holding coastal plants in place. That means “vegetation could fall down, collapse, and be washed away,” says Yang, who works in the Environmental Fluid Mechanics Laboratory under the direction of Heidi Nepf, the Donald and Martha Harleman Professor of Civil and Environmental Engineering.

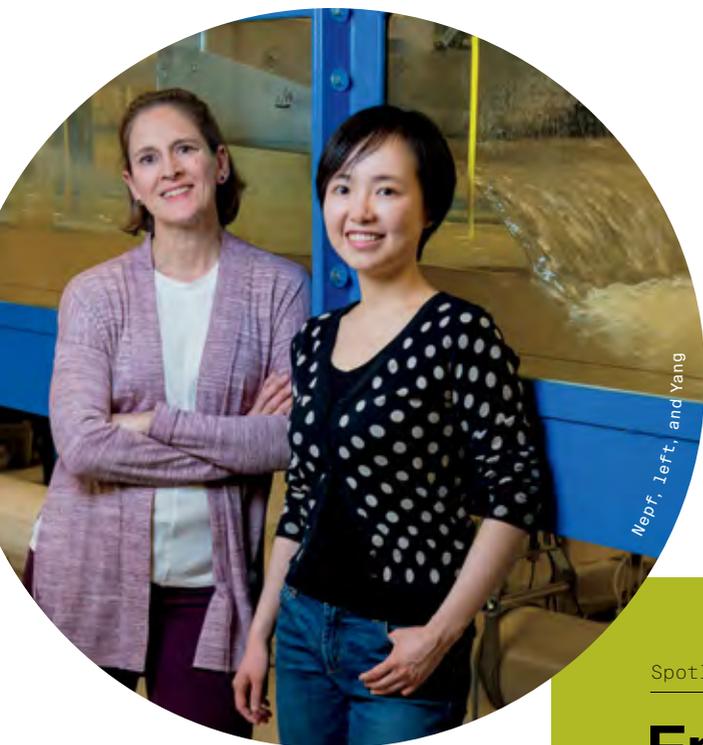
Researchers have worked out numerous equations to model how much sediment gets lost in a system that lacks coastal vegetation. But remarkably, few studies until now

have examined what happens when there are plants present (though it’s clear that the formulas based on a world without them don’t work at all).

## Stepping into the stream

Grasses, seaweeds, and kelps make the computations of fluid dynamics and flow rates much harder. Just think of the whorls you introduce into a river when you pull a single oar through the water. Now imagine each frond or blade throwing off a steady stream of vortices as the water pulses, flowing past and around it. The result is literally dizzying. Yet Yang took on the challenge headfirst, successfully developing a model describing how the movement of sediment is impacted by the presence of vegetation. She’s added in a parameter for plant density, and she’s wrestled with the turbulence that the plants introduce.

To dial in the parameters of her model, Yang set out to build a flume—a water tank 30 feet long. She poured a layer of sand across the bottom, carefully aligned a phalanx of hundreds of thin aluminum tubes to serve as imitation plants, and



Nepf, left, and Yang

## Spotlight on Fellowships

# Enabling Exploration

Judy Yang’s quest to build marshes and wetlands inside her lab, in service of coastal restoration efforts, wasn’t assigned to her. Yang’s choice of PhD project has been a crucial part of her formation as a young researcher. When training to become a scientist, Yang says, “one of the most important things to learn is how to find the question that you’re interested in.”

Graduate student aid she received from MIT—including the Edward H. Linde (1962) Presidential Fellowship and the Martin Fellowship—afforded her the time and freedom to explore a variety of topics until she uncovered the one that became her focus. Yang says the fellowships made it possible to attend seminars and to find communities of like-minded recipients, and this led to her cofounding MIT-TREES ([trees.mit.edu](http://trees.mit.edu)), aimed at communicating topics in environmental science and sustainability to a general audience.

Once Yang graduates, she’ll have a handful of strong publications to show for her efforts at MIT. They’ll be evidence of her ability to model the real world. But Yang’s real power will be in her ability to find her next big idea.

PHOTO: SARAH BASTILLE



Nepf (in orange jacket) works with colleagues from the Water Institute of the Gulf at the field site of Cubit's Gap, in the delta of the Mississippi River.

PHOTO: CHRISTOPHER ESPOSITO

pumped water through the whole operation. Yang used what she observed in the flume to tweak and perfect her equations. She discovered that the eddies and swirls stirred up by vegetation in the water cause quite a bit of sediment to be transported away. “Previous models underpredicted how much sediment is eroded by three orders of magnitude,” Yang says. Her new model gets it right.

Many state and local governments are trying to restore their wetlands. Yang’s model will help inform these efforts, indicating where sediment should be deposited along the coast to maximize retention of the plants. And the benefits of bringing back wetlands extend beyond protecting coastlines from storm surge, erosion, and flooding, says Nepf. They improve water quality and clarity, provide nurseries for certain species of fish, and store a hefty amount of “blue” carbon (an acre of marsh stores more carbon than an acre of forest on land). For a long time, communities developed and implemented human engineering solutions like levees, dikes, and seawalls to deal with erosion and flooding. But people have come to recognize the benefits of a natural solution. “That’s where my lab comes in,” says Nepf.

### Beauty in motion

Yang’s modeling work contributes to a growing set of recommendations for wetland restoration that Nepf and her team are developing empirically. For instance, Nepf explains, her lab is working to determine the specific shoot density and linear extent of marsh or seagrass necessary so that the “flow and wave conditions converge on a sweet spot where the plants have altered the habitat enough to sustain themselves.” Answering such questions allows developers and local governments to make better predictions about how the landscape will evolve with time.

The research has obvious practical applications for protecting coastal communities. But Nepf also does the work because she’s always had a thing for fluid motion. “Some people like to cook—I like to look at water moving,” she says with a chuckle. “It’s very beautiful. It’s so visually intuitive.” Scattered around her office is photographic evidence of her enthusiasm. In a couple of images, fluorescent green dye streams and swirls in blue water. Another photo framed on the wall shows imitation seagrass—a flurry of white ribbons tethered to brown corks—billowing in a controlled current. These snapshots reveal the stunning complexity and splendor of fluid flow.

Yang has seen that complexity up close. Last fall, she spent a few days on Plum Island on the North Shore of Massachusetts, gazing at the marsh grasses dancing in the seawater. She has invested so much time in the lab simplifying the system. But when she watched all that natural movement firsthand, she thought, “Wow.

Spotlight on Professorships

## Building Collaborations

As Donald and Martha Harleman Professor in the Department of Civil and Environmental Engineering, Heidi Nepf examines how water and coastal vegetation interact. Marshland in the Gulf of Mexico, for instance, has eroded over the last century—depriving Gulf states of a protective buffer from storm surge—due to man-made rerouting of the Mississippi River, which once provided a constant supply of sediment and freshwater to the marshes. Nepf has a project with Christopher Esposito of the Water Institute of the Gulf to understand the role vegetation plays in trapping sediment to rebuild marshes. This will inform the design of water diversions that will restore some of the Mississippi’s flow back to the marshes.

This collaboration wouldn’t have been possible without her professorship, she explains. It gave her the discretionary funding to attend a set of preliminary meetings with the Water Institute, which led to the grant that funds the project. Nepf finds it especially meaningful that, while a professor at MIT, Donald Harleman SM ’47, ScD ’50 also worked on modeling natural systems to improve human lives. “It’s an honor to have his chair,” she says.

There are so many parameters, so many variables I have to consider.” Yang dipped her instruments into the water and was surprised to find how large a role the waves were playing within the marsh in generating fluid motion near the bed. “In the future, I will consider these waves to make the model more reliable,” she says. The more reliable it becomes, the better off people will be the next time the skies darken and a violent storm makes landfall, encountering a small but ready squadron of green standing guard. —Ari Daniel PhD ’08

# Regaining Consciousness

The best path to unbiased algorithms? Recognize bias at the source, says marketing expert Renée Gosline

“We have this assumption that algorithms created by computers or artificial intelligence are superior to the human mind,” says Renée Gosline, senior lecturer and research scientist in marketing at the MIT Sloan School of Management. But as we increasingly lean on machines to help us make decisions—a phenomenon that Gosline, whose research focuses on how technology affects our perceptions and behavior, detailed in a recent TEDx talk in Boston on “The Outsourced Mind”—it’s important to examine that assumption. “We may not realize that because the algorithm was programmed by humans or learns from humans, it is prone to human bias,” she says. *Spectrum* spoke with Gosline about why individuals and companies should be concerned about this dynamic, and what can be done to fix it. —Emily Omier

**How can outsourcing our decisions to computers lead to amplified bias? Why is this a problem?**

**RG:** We often assume that machines are rational, objective, and impartial, but that thinking could lead us down the wrong path. One example is in the images that pop up if you search for “female beauty” or “three black teenagers.” In both cases, you’ll see results that show clear racial and gender bias. This shows that machines have a particular idea of what a beautiful woman looks like, and that has implications for the billion-dollar beauty industry as well as for health behaviors.

In addition, chat bots are being used more and more for things like therapy, financial advising, and disease management. If you have a bot that is making assumptions about whether or not you are a good candidate for a loan

based on your demographic information, that could be problematic, especially if that bot has learned discriminatory behaviors.

## (➔)

**ALSO IN THIS ISSUE**  
See page 7 for more on algorithmic bias and other social implications of AI.

Bias doesn’t necessarily refer to racial or gender discrimination, it simply means that there is a nonrational assumption being made that is leading the decision in a direction that may not be objectively the most beneficial. Every company, whether or not it is concerned with social inequality, should worry about cognitive bias in machine decision-making because it can lead to bad decisions.

**What can we do to prevent human bias from crossing over into machines?**

**RG:** We know from behavioral science and behavioral economics that the most effective way to combat cognitive biases is to make the unconscious conscious. To make people aware of these heuristics that are flavored with erroneous or biased assumptions, and bring them to the conscious level, so that people see that they’re jumping to conclusions that may be problematic.

It’s also important to promote inclusivity among the engineers, the leaders, and the strategists who are creating the technologies of the future. By having different perspectives present when decisions are made and architectures are created, you’re far less likely to produce something that is tone-deaf, or, at worst, harmful in terms of leading people down a biased road.

I teach Behavioral Economics and Behavioral Science, and I try to impress on my students that (a) technology is prone to the same biases that humans are, and so (b) it is important, as leaders, engineers, and businesspeople, that when they go out in the world and create the next great thing, they are conscious about unpacking and dismantling their own cognitive biases, lest they end up spreading them through whatever kind of business or algorithm they put forth in the world.

**Why is this so important now?**

**RG:** Now is when this is all being built, so this is the best time for us to be thinking about these issues. Now is the time for us to think about this as we construct this new world.

Technology presents a tremendous opportunity to be an equalizing force. We just need to be mindful that there is a potential dark side to letting the machine take the lead.





# Culture Shift

**Expanding engineers' horizons beyond engineering is essential to addressing the field's gender imbalance, says sociologist Susan Silbey**

Female engineers experience more negative group dynamics in their workplaces than men do, which can cause them to leave the engineering profession more often than men, according to a study co-authored by faculty chair Susan Silbey with several former students and colleagues. Silbey is the Leon (1926) and Anne Goldberg Professor of Humanities, professor of sociology and anthropology, and professor of behavioral and policy sciences at the MIT Sloan School of Management. Much of her work explores the ways in which complex technological organizations govern and observe themselves. Currently, only 13% of the engineering workforce is female. Why do these dynamics occur and persist? The paper, published in *Work and Occupations* and titled “Persistence is Cultural: Professional Socialization and the Reproduction of Sex Segregation,” focused on MIT, Smith College, Olin College, and the University of Massachusetts. The study found systematic differences in the experiences of students from these schools—not by institution, but by gender. For example, women are often marginalized during team-based projects and internships in their undergraduate years—relegated to “managerial and communication” roles, Silbey says, instead of those that require technical acumen. In a candid conversation, *Spectrum* asked her how the role of education in engineering could help to repair this discrepancy. —Kara Baskin

**Why do you think women pursue careers in engineering despite the marginalization they reported in your research?**

**ss:** A large number of them who report negative experiences stay with engineering because they believe they can handle and overcome the obstacles, and that engineering is an objective meritocracy that will appropriately reward them. They are ambitious and confident. When women leave, it's more often because they find it not only a hostile environment, but they also don't think the work will be sufficiently interesting.

**What are the challenges involved in repairing these gender dynamics?**

**ss:** Both men and women have to recognize that it's not an objective meritocracy. Engineers often apply the logic of machines to people, but people are not machines in any of their actions; thus they are not entirely objective. As hard as they may try, they incorporate

**“When people are not open to different kinds of knowledge-making, they tend to stick with what is most comfortable.”**

preferences, prejudices, and commonplace norms into their decisions, often unconsciously. Like most professions, engineering develops local, idiosyncratic criteria that the actors don't always recognize. The problem is that organizations and cultures reproduce themselves. The people who control the resources more often reward those who are like themselves.

We can split the atom and make new materials, but social institutions—and engineering is not only a profession but an institution—are durable because they are hard to change, perhaps harder than matter, and routinely reproduce their habits.

**Is there a way forward through education?**

**ss:** Of course there is, but it requires change. Engineering tries to squeeze everything into four years, and in the process squeezes out ethical, social, and cultural education. Students should be able to explore more, and explore out of their comfort zones. They need to encounter history, political science, literature, and sociology to challenge what they know and are skilled at so that they can learn about other ways of thinking and acting, and yes, other ways of encountering the world, making decisions and solving problems.

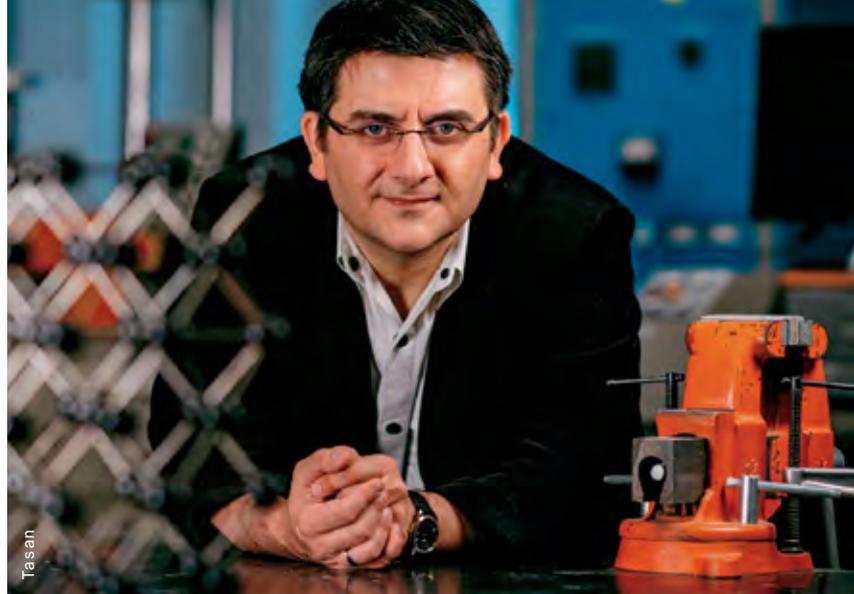
We've overcome the pipeline problem. There are plenty of women highly skilled in what is required for engineering. It is now a local culture problem. We need to provide each student with the opportunities to develop the skills of self-learning and observation of self and others in order to figure out how to manage oneself for lifelong learning. When people are not open to epistemological variety—different kinds of knowledge-making—they tend to stick with what is most comfortable, and that's how you get groupthink, as well as misogyny.

**Your paper notes that any reforms in engineering education aimed at encouraging gender parity must address the workplace as well as curriculum, because workplace experiences are often what discourage women from pursuing engineering careers. And in a recent MIT News interview, you mentioned a potential strategy might be to offer “directed internship seminars.” What would that entail?**

**ss:** I had in mind parallel mentoring and group discussion, perhaps some reading about the internship experience as it was ongoing. Those discussions would not only provide support for the students but would also educate them in organizational and social processes, culture, and professional work. Many sociology departments, for example, offer such internship courses for their students to learn about how organizations work and what the world of work is like. It is both a hands-on practical experience and a scholarly exploration.

# New Life for Metals

Cem Tasan aims to invent repairable, reusable alloys



You're slicing up veggies for your dinner when the knife slips and cuts your finger. Immediately, your body initiates a series of physiological events, developed over millions of years of evolution. Before long, the wound is gone, and you've learned to be a little more careful with sharp objects.

Non-living things, of course, lack this inherent ability to heal: snap a pencil or shatter a window, and they will never be as good as new. In our imperfect universe, all materials, inorganic or organic, inevitably succumb to damage and deterioration. That's why those who build the materials that comprise our lives have always concentrated on making things stronger, tougher, long-lasting. But many materials scientists and engineers are now taking a different approach, creating materials that are either easier to repair or can even "heal" themselves like living tissue.

Most such work has concentrated on soft polymeric substances—plastics, films, rubbers, and paints—because the molecular structure of such materials is easier to break down and alter with readily available techniques. "People have been trying for a long time to come up with mechanisms for physically closing cracks that are nucleating in materials," explains Cem Tasan, the Thomas B. King Career Development Professor of Metallurgy at MIT. "But it's almost impossible in the case of metals,

because the required transformations in metals take place very slowly at room temperature."

The same incredibly strong atomic bonds that make metals so durable also rule out the usefulness of self-healing concepts effective for polymers. "The field of self-healing in bulk metallic materials is in a rather early childhood stage," notes a recent textbook co-authored by Tasan. Uncovering the new knowledge and developing the new techniques necessary to bring that field to maturity is the quest of Tasan and his research group in MIT's Department of Materials Science and Engineering.

Fulfilling that quest, Tasan notes, requires a departure from metallurgists' time-honored

practice of crafting metals and alloys "in terms of strength, ductility, hardness, and other engineering properties." For millennia, that made perfect sense, but in a 21st century facing catastrophic environmental change from carbon-polluting industrial processes such as steel

manufacturing, Tasan argues that reusability and repairability must also be considered.

"Recycling is beneficial from a resource efficiency point of view, but not always from a CO<sub>2</sub> emissions point of view," he notes. "Instead of full recycling processes, feasible metals repair and reuse options need to be developed."

## Showing the cracks

Metals rarely fail for a single reason. They may undergo constant or repeated physical strains, temperature changes, pressure variations, hydrogen embrittlement, and many other effects that are still only partially understood. All these stresses accumulate over time, resulting in the formation of microscopic cracks and voids that weaken the metal's structure. As the weakened metal loses its ability to withstand the stresses, the microscopic cracks coalesce to form macroscopic cracks. Ultimately, the metal fails completely, with consequences that can range from inconvenient (a broken door hinge) to catastrophic (an airplane crash).

So Tasan's first major objective, he explains, "is to develop novel techniques that give us a clearer physical understanding of how metals fail under different conditions, so that we can interrupt these processes with certain treatments and either remove the damage or reverse the process of damage accumulation."

"To be able to apply a repair treatment, one first has to understand how the microstructure, the atoms and the bonds and the crystals, evolve as a result of the external conditions," Tasan says. So he and his team subject metal specimens to various stresses under tightly controlled laboratory conditions. They have designed machines that deform or put hydrogen in metals, for example, inserting those machines into electron microscopes, then observing failure processes in situ and in real time.

Armed with such nanoscale insights, Tasan is devising better ways to repair existing metals. Repair strategies and treatments vary depending

Tasan took some hints from the structure of bone tissue to design a form of steel with a layered microstructure capable of both resisting the formation and restraining the propagation of microscopic cracks.

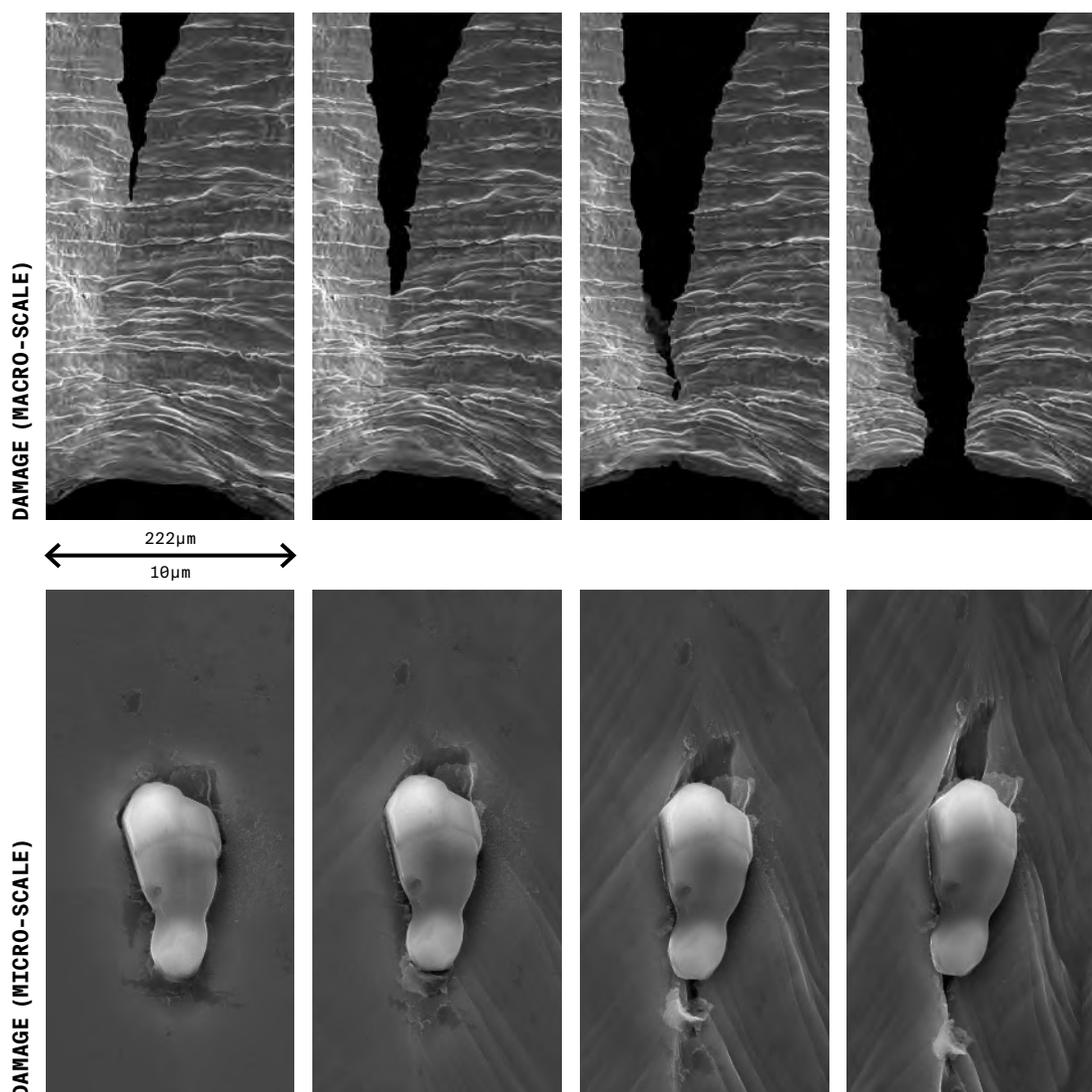
on the damage mode, and can involve local or bulk heat treatments and deformation processes, among other approaches. As Tasan explains, there are two consequences of damage evolution during metal failure. “One is a structural change that is also causing a change in properties, and the second is a change that is related to the form of the component, the shape of it. There are failure mechanisms that don’t change the shape of a component at all but cause an abrupt failure, and there are failure modes that change the shape and also the structure.”

Failure modes that don’t involve shape change are generally more conducive to repair treatments, but there’s a complication. “Metals were never designed with the idea of reusability,” Tasan points out, “so many of our alloys have either unknown or limited reparability.”

### Microstructures inspired by nature

That leads to the second aspect of Tasan’s work, developing new metallic materials. “We have to make sure that we put sufficient effort in following a parallel route in updating our material design, so that the material can respond to even simpler repair treatments. Ideally you just want to repair the component without replacing it, by applying a short, feasible treatment for a second, not putting it in a furnace at a thousand degrees for a week.”

One of Tasan’s recent projects addresses the fatigue process in metals, which can lead to failure due to cyclic stresses. “Typically, the structural materials we use today are tough,” he notes. “Even when a micro-crack is nucleated, the materials’ microstructure can arrest the micro-crack to avoid its growth. The problem is that the mechanisms involved with the arresting of the crack, such as local plasticity and phase transformation, are one-time mechanisms. So if there’s another stress cycle, the crack will propagate.” Tasan took some hints from the structure of bone tissue to design a form of steel with a layered microstructure capable of both resisting the formation and restraining the propagation of microscopic cracks. The material, still in the testing stages, is suitable for scaling up for commercial applications. It’s a highly promising example of Tasan’s approach, which he prefers to call “structural resetting” rather than “self-healing.” (“We’re not trying to create alloys that close cracks themselves,” he clarifies—“we’re trying to create alloys that have tough microstructures that, once damaged, can be repaired easily to retain their original crack arresting capability.”)



Even with the practical economic and environmental benefits that easily repairable metals can offer, Tasan acknowledges that “there are certain applications where it just doesn’t make sense.” For example, his group abandoned its interest in designing reusable bolts after realizing the construction industry would be unlikely to go to the trouble of repurposing such a small, inexpensive component after it had sat in a building for decades.

Larger and more expensive metal components such as airplane or automobile parts are a different story. When such parts are failing, weakened by one or more fatigue cracks, 99.999% of the metal is still in good shape. “Imagine you could apply a treatment that would play with the atomic structure to avoid or to delay this process,” he says. “Then it makes a lot of sense, because by treating only 0.001% of the material, you save the rest.”

And it’s more than costly equipment that is being saved: Tasan sees his work as a worthy strategy to reduce carbon emissions and fight climate change. “If we do not come up with ways of reusing and repairing materials, there’s no way that we can cut down CO<sub>2</sub> emissions to reasonable levels,” he says. —Mark Wolverton

Mark Wolverton is a 2016–17 MIT Knight Science Journalism Fellow.

Damage in metals is initiated at the microscale (bottom), leading to a macro-scale crack (top).

IMAGE: CEM TASAN

# Redefining Resilience

**MIT experts mobilize to help hurricane-struck islands not only repair, but rebuild for a safer future**

Last September, just days after the second of two powerful Atlantic hurricanes laid waste to Puerto Rico and several adjacent islands, Robert Stoner decided MIT needed to act. “We have a lot of capability here,” says Stoner, director of the Tata Center for Technology and Design at MIT, and deputy director for Science and Technology at the MIT

Energy Initiative (MITEI). “There are world-class people in the areas of disaster relief, electrification, regulation, water systems, transportation, and finance. We needed to show the people in those islands that MIT cared.”

Stoner reached out to his colleague Donald Lessard of the MIT Sloan School of Management. Together with various student groups, they reached out to other colleagues,

who in turn reached out to more. In a short few weeks they organized a major conference, which took place over two days in early December. Faculty from across MIT met with representatives from many of the affected Caribbean islands, assessing the damage to those nations’ electrical grids, housing, water systems, and roads, and drafting strategies to both rebuild them and make them more resilient.

During the event, Keith Mitchell, prime minister of Grenada, noted that global warming had created “an existential threat” to Caribbean nations facing dramatic rises in sea levels and hurricanes of increasing ferocity. Ricardo Rosselló ’01, governor of Puerto Rico, reported that close to half a million homes had been destroyed or severely damaged, and that the island’s power grid and water systems had been severely compromised—and all that in the context of a dramatic debt crisis that had crippled Puerto Rico’s capacity to borrow. “The hurricane happened on an island that was already battered by a hurricane of the man-made kind,” said Rosselló, who graduated MIT with a degree in chemical engineering.

The December conference, while significant, was only the first step in MIT’s ongoing effort to bring its expertise to relief and reconstruction efforts in the Caribbean and perhaps more importantly, to develop a template that can guide the Institute’s response to future disasters. “We held sessions on housing, electricity, water systems, and finance,” says John Fernández ’85, professor of building technology in the Department of Architecture, and director of MIT’s Environmental Solutions Initiative. “But the concept that dominated our conference was the ongoing tension between the need for an immediate response, and the desire to build long-term resilience. There are lives to be saved. Houses and infrastructures need to be rebuilt. Still, we all agreed it was time to stop doing

Puerto Rico’s governor, Ricardo Rosselló ’01, left, visited campus in December to discuss the challenges facing his island with MITEI and the Tata Center’s Robert Stoner.

PHOTO: JUSTIN KNIGHT



Lawrence Vale, left, and Miho Mazereeuw, both professors in the School of Architecture and Planning, are applying their expertise in resilient housing and disaster response to the current situation in the Caribbean.

PHOTO: JUSTIN KNIGHT

business as usual. Simple reconstruction merely restores the systems that have already failed.”

### The short term and the long term

A first measure, Fernández suggests, is building dwellings and infrastructure that can withstand the Caribbean environment—a region that due to climate change will be hit with increasingly ferocious storms whipping up winds of

150 or even 200 mph. “We already tend to build for high winds in places like Florida,” says Fernández. “But apart from Bermuda, where they’ve built in concrete and stone forever, it’s just not done in the Caribbean, due mostly to socioeconomic conditions there.”

The tension between immediate response and long-term resilience is not limited to the Caribbean or to developing nations. Consider Houston, Texas, which suffered disastrous flooding during Hurricane Harvey this past August. Fernández recognizes the value MIT student and faculty groups can provide in Puerto Rico, Grenada, and their neighbors, offering labor and supplies, expertise, and bringing best practices to those islands—but he thinks the Institute’s work in the Caribbean will pay dividends in seas and lands all over the earth. “I believe at least half of the value of our involvement in the Caribbean will be about transferring what we learn there elsewhere,” says Fernández. “Our work will impact people who live on these islands. But the general principles will apply to every city and human settlement. We now understand the problem of the short term and the long term. We know the steps to take to bring these islands up to best practices. There was a lot of excitement at the conference that we could actually solve this.”

Part of the solution, for conference attendees and for future relief and reconstruction projects, will involve developing a new definition for resilience. Lawrence Vale SM ’88, who helped moderate a panel on human settlements at the December conference, argues that it is not sufficient to



reinforce buildings and systems to withstand powerful natural disasters, or to rebuild houses—no matter how strong and sturdy—on the first piece of available land. “If we really want to talk about resilient housing and cities, we first have to ask whether this new housing is safe from future risk,” he explains. “Will it be an asset for the people who are destined to live there?”

For Vale, Ford Professor of Urban Design and Planning who also directs MIT’s Resilient Cities Housing Initiative, well-built housing on environmentally sound land is only one element in the creation of resilient housing. “When we rebuild after a disaster, we need to ask ourselves what we are doing to help people connect to their neighbors, their

communities, and their full lives,” says Vale. “After a disaster, the tendency is just to build quickly, and this often disrupts the networks that people depend on to lead viable lives. It’s a case of getting the house right and the job wrong.”

Vale cites the examples of post-tsunami Indonesia, and that of northern Colombia, where violent landslides displaced thousands of neighborhood residents. “In both cases, the people who came to rebuild saw the survivors as victims, as desperate people they were rescuing with this new housing.

“The concept that dominated our conference was the ongoing tension between the need for an immediate response, and the desire to build long-term resilience,” says Fernández. “Simple reconstruction merely restores the systems that have already failed.”



What they didn't see was that these so-called victims often owned their own land, that they grew food, that they had jobs and families nearby—that they were able to live a complete life, despite low incomes. After reconstruction, they may have had houses that looked better in photographs. But the houses were nowhere near their jobs or affordable transportation.”

**Financing the future**

Building resilience requires not only willpower and knowledge. Relief supplies need to be purchased and delivered. New houses need to be paid for, and costly power grids or water systems somehow financed. “Spending extra funds to build resilient infrastructure is almost always a good idea,” says Donald Lessard, the Epoch Foundation Professor of International Management at the MIT Sloan School of Management. “But it’s hard to capture the future value and raise money for the additional investment in the present.”

Lessard, who moderated a panel on funding sources for resilient reconstruction at the December conference, says a first step would be for these countries to insure their infrastructures. “We now understand that the Caribbean is going to have a 100-year storm, say, every five years,” he says. “Even a small country can purchase insurance. This will require an up-front payment, but perhaps it can embed the cost of that insurance

in the money the country receives from donors or lenders. And then it can invest in ways to make that infrastructure truly sustainable—raising equipment 20 feet off the ground, or building highways with better runoff. The next time a catastrophe hits, the insurance proceeds will offset income losses and they can rebuild again. If insurance underwriters were on their game, they’d realize the value of these investments and

reduce the premiums. We’re not living in that ideal world yet, but many Caribbean islands already participate in a regional catastrophe risk pool, and we also have instruments like green bonds and catastrophe bonds that serve this purpose.”

Lessard and his colleagues recognize that finance is only part of the solution to providing relief and creating resilience in the Caribbean and in other regions threatened by climate change. They also realize that while many disasters may share similar elements and consequences, each one of them is ultimately unique. “We recognize that all disasters are local and there is no one-size-fits-all solution,” says Miho Mazereeuw, a professor of architecture and urbanism who directs MIT’s Urban Risk Lab. “This certainly holds true for Puerto Rico.”

The US island commonwealth is currently saddled with \$70 billion in bond debt. Forty-five percent of its residents are living under the poverty line and 12.5% of them are unemployed. Yet because Puerto Rico is neither a country nor a state, it cannot devalue its currency or declare bankruptcy. “From the top, Puerto Rico has financial troubles that create challenges for its government,” explains Mazereeuw. “Despite widespread poverty, there is a tremendous amount of energy in the island’s community-based efforts, and yet the unregulated housing and diverse terrain make recovery extremely complex. Even within the island there are discrepancies. Things are more or less returning to normal in San Juan, the capital. But many

“If we really want to talk about resilient housing and cities, we first have to ask whether this new housing is safe from future risk,” says Vale. “Will it be an asset for the people who are destined to live there?”



In January, MIT architecture students helped construction workers repair damaged homes in Villalba, Puerto Rico, with assistance from the Foundation for Puerto Rico (founded by Jon Borschow '72).

PHOTO: LUISEL ZAYAS

**(↗)**

**READ MORE**  
MIT student efforts in Puerto Rico  
[alum.mit.edu/slice/mit-students-focused-puerto-rico-recovery](http://alum.mit.edu/slice/mit-students-focused-puerto-rico-recovery)

of the smaller, remote towns are still struggling.” To help to address the difficulties these communities are facing, the MIT Urban Risk Lab is working to develop alternative models for post-disaster housing in Puerto Rico and other contexts.

MIT’s December conference kicked off a series of initiatives for the Institute to help bring its expertise to the Caribbean. Several teams have traveled to the region to build roofs, to advise on recovery and reconstruction, and to interview residents and relief workers. Faculty members have held follow-up meetings, consulted with regional officials and agencies, and have briefed MIT President L. Rafael Reif on their progress. It’s not the first time MIT has stepped up to provide relief. But there is something different in this effort.

“Every time a natural disaster occurs, MIT moves to help,” says Mazereeuw. “But whether it’s Nepal or Mexico or Colombia, it’s been an ad hoc process. This is the first time we’ve made a point to come together before we’ve drafted our individual courses of action. I think this conference has set a good precedent for how we respond in the future.”—Ken Shulman

From left, Keith Mitchell, the prime minister of Grenada, and MIT professor of electrical engineering Cardinal Warde, a native of Barbados.

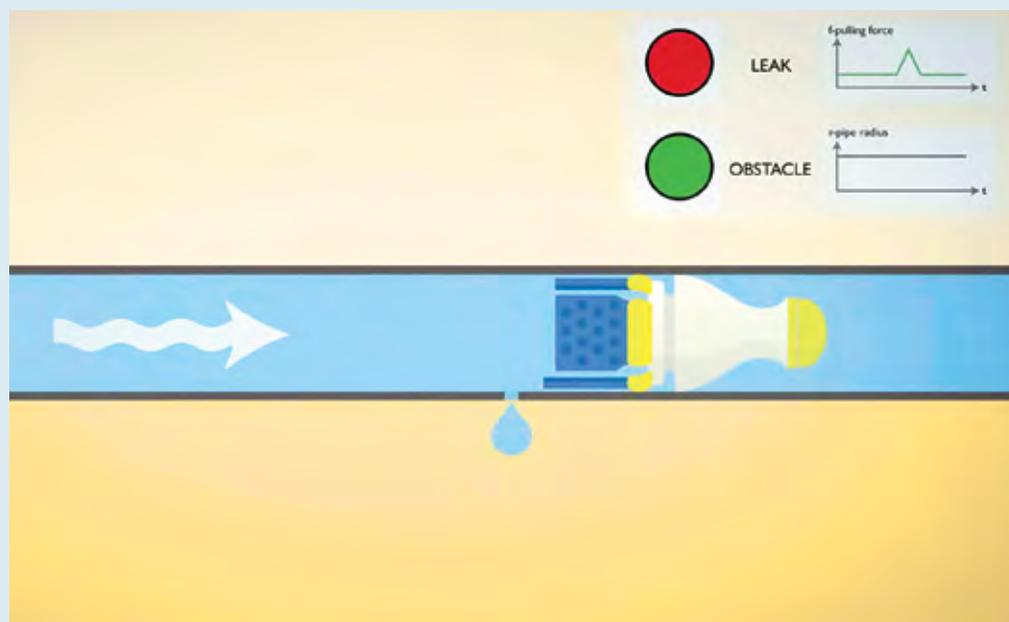
PHOTO: JUSTIN KNIGHT



## Detecting Leaks from Inside the Pipe

A leak in a city’s water pipes can go quickly from drip to disaster, both in lost resources and in accompanying damage. A device to address this challenge, with additional applications for gas and sewage lines, is being commercialized by the newly founded PipeGuard Robotics. The soft robot was developed in the lab of mechanical engineering professor Kamal Youcef-Toumi SM ’81, ScD ’85 and has been field tested in the US, UK, and Saudi Arabia. PipeGuard’s founders—You Wu SM ’14, PhD ’18, Jonathan Miller SM ’18, and Daniel Gomez MBA ’18—aspire for their invention not only to detect leaks but, eventually, to be able to repair some of them on the spot. In the meantime, here are a few key features that allow it to discover and assess leaks before major repairs are necessary.

—Nicole Estvanik Taylor



### 1 Nicknamed “Lighthouse” and “Daisy,” these rubbery robots are all about flexibility.

Designed in two different sizes for use in pressurized pipes, they are propelled by water flow, can squeeze past small blockages, and are bendy enough to navigate sharp turns. The team is also developing a self-propelled version.

### 2 The robots’ fin-like, tactile sensors can detect leaks as small as 1 gallon per minute.

The fins fill the diameter of the pipe and are stretched whenever they encounter the suction force of escaping water. Because obstacles such as dirt in the pipes compress the robots’ housing as well as stretching the fins, they can differentiate between leaks and blockages.

### 3 Lighthouse and Daisy can be used without any digging or interruption in water service.

An operator can use a robot launcher to insert the robot into a T-junction or fire hydrant, then may retract it via tether or recapture it at a downstream location. A cloud-based analytics platform provides the operator with a map of leaks, including leak size and repair recommendations.

# Greening the Block

**Over the past four decades, Anne Whiston Spirn has made the West Philadelphia Landscape Project a model of urban restoration and community empowerment**

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Back in the 1980s, when Anne Whiston Spirn was studying the urban ecology of Boston, she made a fascinating discovery. Much of the vacant land in the city's most blighted neighborhoods mapped perfectly onto the floodplains of streams that had long since vanished. The more she examined it, the more she saw correlations—water-damaged foundations leading to a vicious circle of decaying buildings and disinvestment in the neighborhood.

From that revelation has come a major part of Spirn's life work. "So often, funding for environmental projects has been pitted against funding for social projects," says Spirn, who is now the Cecil and Ida Green Distinguished Professor of Landscape Architecture and Planning at MIT. "My vision has been to imagine how to address the restoration of the urban natural environment at the same time as rebuilding the human community." Her

main field of study has been West Philadelphia, where for the past 40 years she has worked to put theory into practice, working with community members to transform their neighborhood through the West Philadelphia Landscape Project (WPLP).

Coming to the University of Pennsylvania as chair of landscape architecture in 1986, Spirn took charge of a university project to "green" the neighborhood of Mill Creek to attract new investment. Instead, she proposed a restoration of the former valley bottom, with a park that would absorb stormwater, thereby reducing combined sewer overflows, while at the same time creating space for community gardens, public art, and recreation. Other vacant land, she proposed, could be used as tree nurseries to reforest the streets among other uses. The city rejected her proposal in 1994, and built a

new grocery store and new housing on Mill Creek's "buried floodplain."

Undaunted, Spirn continued to work

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The Aspen Farms Community Garden has been a WPLP partner since 1988.

PHOTO: ANNE WHISTON SPIRN



with a predominantly African-American community to achieve the vision together. Even in the midst of one of the most impoverished neighborhoods in the city, she found “islands of renewal,” families with beautifully maintained homes that could create the seeds for rebirth. “I found them to be reservoirs of high energy and resources,” says Spirn, who worked alongside them to transform vacant lots into community gathering spaces and bolster existing spaces such as Aspen Farms, an oasis of vegetable and flower gardens.

Her biggest impact, however, was achieved through education. Starting in 1996, Spirn and her UPenn students spearheaded a curriculum at the Sulzburger Middle School to teach eighth graders about the environmental and social history of the neighborhood and propose new projects for its repair. The teens learned HTML and created their own website about the neighborhood. During a summer program, they wore blue shirts that said “Ask Me About Mill Creek,” educating their neighbors. “They became ambassadors and interpreters for adults and other children about the landscape and history of the neighborhood,” she says—and increased the program’s visibility.

In 1998, the governor of Pennsylvania invited the students to make a presentation as part of his state of the state address, and in 2000 President Bill Clinton visited the school. City engineers asked Spirn for a tour of the watershed, and “by the end of a beer or two, we’d agreed that the water department would put in a proposal to the EPA for a grant to do a demonstration project.” That project came at least partially to fruition; however, in 2002 Sulzberger Middle School was taken over by a private corporation that cancelled the place-based program, and many elements of the project remained unimplemented.

By that time, Spirn had joined MIT’s faculty. It would take another decade before Philadelphia finally implemented its Green City, Clean Waters program, which has since become a national model for the use of green infrastructure to reduce combined sewer overflows. Spirn takes credit, at least, for planting the seeds that eventually grew into the program—even as she continues to work



“So often, funding for environmental projects has been pitted against funding for social projects,” says Spirn. “My vision has been to imagine how to address the restoration of the urban natural environment at the same time as rebuilding the human community.”



in the Mill Creek neighborhood on new projects with MIT students.

The greater legacy of the program may reside in the children it inspired, some of whom have gone on to work in computer coding and web design themselves. “Every community, no matter how poor, has enormous resources and people of great intelligence and leadership skills who have a better knowledge than policymakers about what will work in their neighborhood,” Spirn says. “Repairing the urban natural environment has to go hand in hand with community reparations and the empowerment of youth.”

—Michael Blanding

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West Philadelphia middle school students, 1999. Students working with WPLP have learned to read their landscape as a product of natural forces and social, economic, and political processes.

PHOTO: ANNE WHISTON SPIRN

# Minding the Gap

**The first US-focused MIT Sloan action learning course grapples with the divides in American society**

For 20 seconds, the instructor paused and allowed an increasingly uncomfortable silence to fill the room. “If you’re talking, you’re not listening,” senior lecturer C. Christine Kelly finally said—underscoring a central point of USA Lab, a new class offered through the MIT Sloan School of Management.

Founded to contribute to bridging the national fault lines exposed by the 2016 presidential election, USA Lab joins MIT Sloan’s suite of “action learning labs,” experience-based courses in which students put their lessons to work on real-world projects. It is the first to center on the United States.

There are no quick fixes for America’s deep economic, cultural, and geographic divides, says senior lecturer Barbara Dyer, who co-teaches the class with Kelly, along with the George Maverick Bunker Professor of Management Thomas Kochan and senior lecturer Leigh Hafrey. “The only real solution is the time-honored, time-consuming task of listening and hearing one another,” says Dyer, who is also executive director of MIT Sloan’s Good Companies, Good Jobs Initiative.

A semester-long course, USA Lab begins by introducing students to the challenges facing many regions of the country and exploring their historical antecedents through readings and discussion. The centerpiece of the class is a project that gives students hands-on experience working with community partners to improve conditions.

“USA Lab is exactly the kind of opportunity that drew me to Sloan, one that provides an opportunity to make an impact at the intersection of academics and managerial action,” says Emily Ullmann, a first-year MBA student in the class. “As the 2016 election made clear, the US must reconcile its preferred narrative of progress and inclusivity with the impacts of a cultural divide and the legacies of legislative and economic oppression. To me, this challenge is one that will require the principled innovation that drives Sloan, and MIT more broadly.”

To begin the process, the class features lectures on topics ranging from “Race, Class, Culture, and Resilience” to “Work and the American Dream.” Students also read a variety of texts, including sections of J.D. Vance’s *Hillbilly Elogy* and Arlie Hochschild’s *Strangers in Their Own Land*. According to Jared Johnson, a first-year MBA student working on a dual degree with Harvard’s Kennedy School of Government, the instructors have created an environment where students who want to engage with these topics can challenge their own thinking. “They’re really trying to provoke discussion and are asking tough questions,” he says.

In addition to laying the intellectual groundwork, the USA Lab class pairs student teams with community development organizations across the country to grapple firsthand with the issues rural regions face.

This year, students worked on job growth in Maine with Coastal Enterprises; evaluated the business case for child care for the Community Foundation of Greater Dubuque in Iowa; analyzed financial service offerings in the South for Hope Enterprise Corporation/ Hope Federal Credit Union; assessed barriers to workforce development in Michigan for the Pennies from Heaven Foundation; and explored challenges facing the seafood sector in Oregon for Rural Development Initiatives.

“To spend two weeks in a rural community, understand it, and provide value seemed a unique opportunity,” says Hilary Gram, a second-year MBA student who partnered with Coastal Enterprises to analyze the market for Maine’s agricultural products.

**“The only real solution is the time-honored, time-consuming task of listening and hearing one another,” says Barbara Dyer.**

MIT Sloan Fellow Faisal Seraj says he was inspired to sign up for USA Lab after he attended “Taking on the Divide: Good Jobs and Shared Prosperity in Rural America,” a panel discussion sponsored by Mens et Manus America at MIT last November that spotlighted regions left behind by America’s economic growth. “It felt a bit surreal to hear this issue in an advanced economy like the United States,” says Seraj, who works for the international development organization BRAC.

Seraj says he hopes that examining America’s divides—and attempting to bridge them through USA Lab—will reveal ways to encourage more equitable growth around the world. “There is a lot of learning to be done.” —Kathryn M. O’Neill

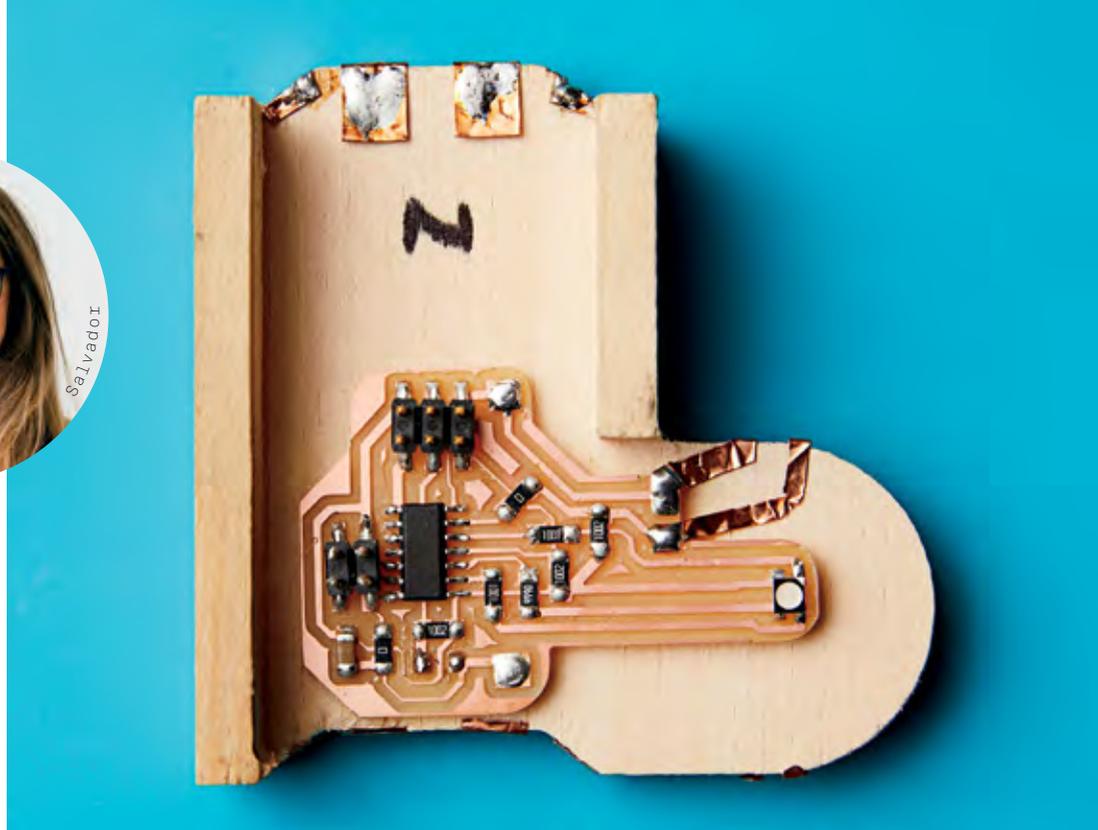
A group of USA Lab students spent two weeks in Maine learning about the state’s agricultural sector, with visits to sites including the Blue Ox Malthouse (pictured) in Lisbon Falls.

PHOTO: BEARWALK CINEMA



# How to Make Almost Anything Better

A media arts and sciences grad student learns to debug, with a little help from her friends



How to Make (Almost) Anything is a community as much as it is a class. From the title of the course, I knew that I'd be stretching my brain and limits as I attempted to master a variety of fabrication skills. However, I never imagined that the best lessons and ideas I'd get in the class would be learned through my peers.

A little background: [MAS.863/4.140/6.943] How to Make (Almost) Anything—taught by Professor Neil Gershenfeld, the director of the Center for Bits and Atoms—is an institution 20 years in the making. Started in 1998, the course was designed to expose technical students to advanced fabrication equipment and techniques, but it ultimately grew into something much more rewarding. In its current iteration, students marry creative visions with technical implementation in empowering and novel ways, ultimately to create a final project that combines all the skills acquired during the semester.

I came up with TRAX (pronounced “tracks”), a toy aimed at teaching the fundamentals of music composition in an intuitive, physical way. I designed tracks of different lengths corresponding to rhythmic values (for example, the longest piece represented a half note, while a track half that length represented a quarter note). Each track had an LED light to indicate note value (for example, if the track LED was red, it would play the note “C”).

Through the marathon of final presentations, what stood out most was how each project reflected its maker's interest and personality. These final projects showcased the power of making and self-expression in imaginative ways.

And, as a community, we made our projects better. There was a moment during the final push to finish the projects when I nearly gave up. I had been debugging infrared LEDs and phototransistors for *hours* in the middle of the night. I still couldn't figure out why the serial monitor kept spitting the same value back at me, no matter how close the LED and phototransistor were. To understand how frustrating this is, you

should know that phototransistors are basically tiny cameras that detect defined wavelengths of light and return a value between 0 and 1,024 depending on how much light they see. I figured I must've blown up the LEDs, but I had no way to visually inspect because infrared is outside humans'

I switched out all my components, and voilà, it worked! Plus now I had a fun, new way to interact with my musical train tracks, through my phone's flashlight.

Salvador designed and built from scratch a set of wooden tracks that play music when a toy train slides over them.

PHOTO: KEN RICHARDSON

asked me why I needed to use infrared light. Turns out, she was using components similar to mine (LEDs and phototransistors), but in the visible spectrum to coax a swarm of robots to chase or hide from her phone's flashlight. She's brilliant. Anyway, I switched out all my components, and voilà, it worked! Plus, now I had a fun, new way to interact with my musical train tracks, through my phone's flashlight, as my new phototransistors would be able to detect white light.

I can point to so many fortuitous exchanges of wisdom over the course of the semester—fleeting moments that challenged my work and ultimately allowed me to create something better than I could on my own. And, for that, I am so grateful. I learned the skills to make—and debug—almost anything, but more importantly, I found that the most rewarding tool is a community to support and inspire each member. —Emily Salvador '16

*Emily Salvador '16 majored in computer science and music as an undergraduate at MIT and is now a first-year master's student at the MIT Media Lab. This essay originally appeared as part of the “Grad Life” series on the MIT Alumni Association's Slice of MIT blog (slice.mit.edu).*

visual spectrum, and I was way too mentally drained to try to wrestle with a voltmeter.

I ran down to the shop to grab new LEDs and one of my classmates, Agnes, stopped me, probably sensing my frantic vibe. I told her my predicament, and then she

# MIT.nano Comes to Life

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***“MIT will construct, at the heart of the campus, a new center for nanoscience and nanotechnology. An advanced facility open to the entire community of faculty, researchers, and students. A convening space to spark collaboration and cross-pollination. A hive for tinkering with atoms, one by one—and for constructing, from these fantastically small building blocks, a future of infinite possibility.”***

That was the promise that hovered over the former site of Building 12 when the construction of MIT.nano began in 2015—the vision that motivated the generosity of numerous MIT supporters who shared it. This summer, with construction substantially completed, the team behind the long-awaited facility will begin to move in its first tools. In the fall, MIT will celebrate the building’s opening and students will attend class in the chemistry undergraduate teaching labs on its top floor. Philanthropic support will continue to be essential in enabling more than 2,000 researchers per year to use the facility to advance a range of fields, including health and life sciences, energy, computing, information technology, manufacturing, and quantum science.

As MIT.nano springs to life, *Spectrum* spoke with the facility’s inaugural director, Vladimir Bulović, Fariborz Maseeh (1990) Professor of Emerging Technology.

**How will this new building advance the nano education, research, and innovation already thriving at MIT?**

**vb:** Nano is not a specific technology but rather a revolutionary way of understanding and working with matter. Most of MIT’s recently tenured science and engineering faculty advance their work through the understanding of nanoscale science and nanotechnology. They are building the future, and MIT.nano will assist them in any way needed. Researchers and innovators, as well as our partners, will share access to a broad and versatile tool set that can do more—imaging, synthesis, fabrication, prototyping—entirely within the facility’s protective envelope. This is also the beginning of a new era of nano education at MIT, with integrated hands-on learning spaces and advanced teaching tools.

MIT.nano will support the work of both existing and emerging centers of nano research at MIT, such as the recently launched SENSE.nano that develops nano-enabled sensors and sensing systems. Such “centers of excellence” coalesce the intellectual pursuits of a set of faculty, providing a unifying voice that instructs MIT.nano on the instruments and facilities that would benefit those pursuits.

**Can you talk more about those instruments?**

**vb:** There is a multistep process for requesting new tool sets, typically starting with a proposal by

“Most of MIT’s recently tenured science and engineering faculty advance their work through the understanding of nanoscale science and nanotechnology. They are building the future, and MIT.nano will assist them in any way needed.”

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Construction on MIT.nano is now substantially completed.

PHOTO: JOHN COLE

a faculty member. Even after it is fully outfitted, 5% to 10% of MIT.nano’s tools will be updated every year.

Among the first tools to be installed will be a set of two cryo-electron microscopes—the technology that earned its inventors the 2017 Nobel Prize in Chemistry—that will allow structural biologists to analyze complex and flexible structures, such as folds in protein chains, at the resolution of better than 0.3 nanometers [billionths of a meter].

**How can the broader campus community and general public interact with the new building?**

**vb:** The first- and second-floor corridors are public galleries that will showcase advancements developed at MIT.nano and around campus. Lobbies on the east and west sides provide public seating, and sprinkled throughout the building are nooks with whiteboards for brainstorming, tables for collaborating, conference spaces, and a large basement classroom brightened by a skylight. A courtyard path on the south side of the building, named the Improbability Walk, runs parallel to the Infinite Corridor all the way to Building 10. And to the north of the courtyard’s staircase, a plaza

canopied by trees will offer a unique place for public gatherings in the shadow of MIT’s Great Dome.



**LEARN MORE**

[mitnano.mit.edu](http://mitnano.mit.edu)  
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# Alumni Take Action for Students

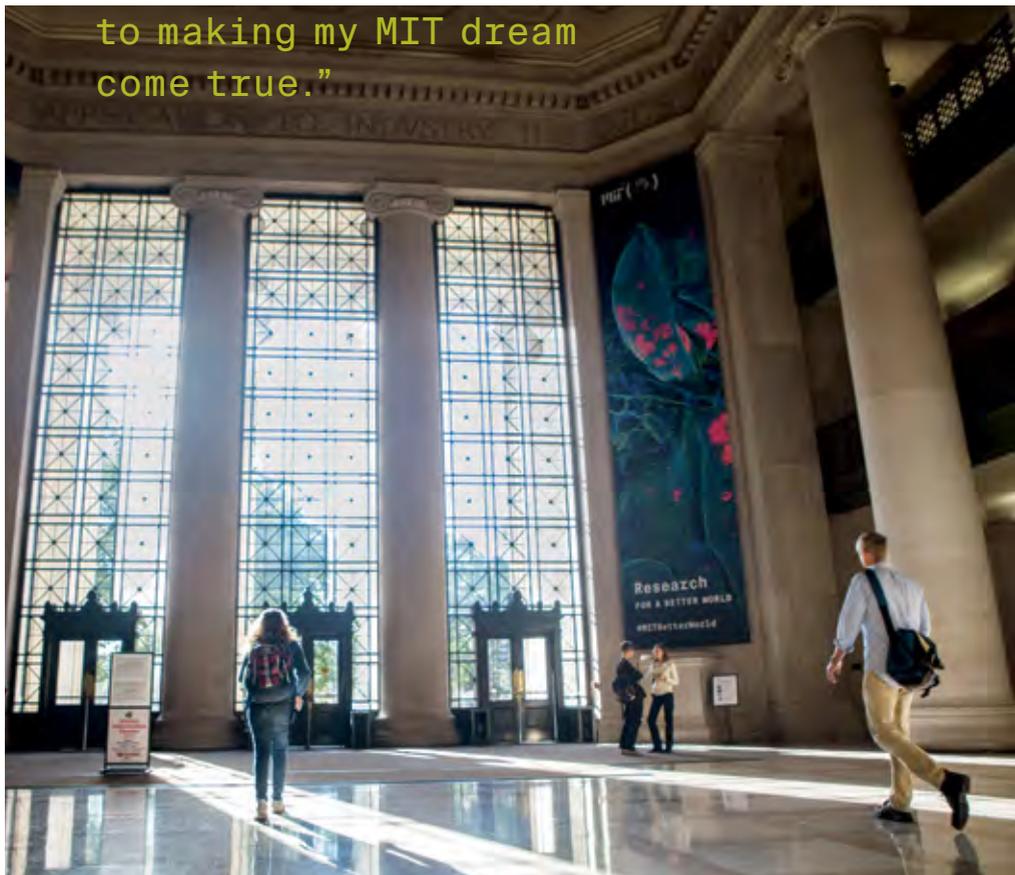
Each student who comes to MIT finds his or her own lasting experience of community. Recent thank-you letters from scholarship recipients reveal that one student's highlight is "being part of the largest dance troupe on campus"; for another, it's "serving in a soup kitchen every week"; for yet another, it's "traveling to Japan and learning about my heritage." Just to come to this community, however—or to stay in it—many students struggle with personal and financial challenges. Knowing all too well how difficult that can be, many in MIT's wider community of alumni have banded together with support of those students in mind.

**"I feel a special bond to those who are first in their family to go to college."** So says **JOHN VELASCO '05, SM '06**, who brought his classmates together to establish the Class of 2005 FirstGen Scholarship Fund, which offers four-year scholarships to students who are the first in their families to attend a four-year college. "As a FirstGen," he says, "I know from personal experience how critical alumni support was to making my MIT dream come true." Organizing the FirstGen Fund took place in the lead-up to the Class of 2005's 10th Reunion. The class voted to establish the fund and donated enough to endow it. Currently one MIT student receives this scholarship, and Velasco says the fund "continues to generate sustained support from classmates each year."

**In the 1960s, ERNEST COHEN '64 was one of just 12 African-American students on campus.** "One of the main goals for BAMIT [Black Alumni at MIT] upon its founding in the late 1970s was to 'give back' by financially assisting black MIT students," Cohen recalls. "After many discussions, a fund was formed, and a nucleus of 30-plus donors stepped forward. Through the years since, more and more black alumni, with their corporate matches, supported the BAMIT Fund, and it steadily grew." Cohen and **KENNETH ARMSTEAD '75**, both former BAMIT presidents, played pivotal roles in renaming the scholarship in honor of astronaut and physicist Ronald McNair PhD '77, whose promising career as a space shuttle mission specialist was cut short by his death in the 1986 *Challenger* explosion. "Like McNair, I came to MIT from the South and was enthusiastic about math, science, and music," says Cohen. "And, like Ron McNair, I was blessed with black high school teachers who were well educated, with master's degrees, and who personally nurtured my development." The Ronald E. McNair (1977) Scholarship Fund has supported at least three scholars per year since 2009. One early recipient was Kristala Jones Prather '94, who is now the Arthur D. Little Professor of Chemical Engineering at MIT.

**"We want students to feel comfortable asking for help when they need it."** That's how David Randall, senior associate dean of student support and well-being, summarizes the spirit of the Class of 1954 Good Samaritan/Mitzvah Fund. Still in its early stages, the fund puts aid in students' hands during times of crisis. **HARVEY STEINBERG '54** and **JOE BLAKE '54** came up with this idea together. As Blake explains: "Emergency is one word, but there is a certain circumstance for students who fall through the cracks—if a student isn't eating, they can't do the work." MIT looked to Randall to administer this new type of spontaneous aid. "Most students who come to us need something immediately," Randall explains. "All students have to do is visit their dean in Student Support Services and identify a need." The department is spreading word to students about the emergency funds in part through a new coalition called Accessing Resources MIT and through a new Emergency Fund & Food Resources website. Usually quiet about giving, Blake says he is now willing to speak passionately about fundraising because, as he puts it, "I see the letters of thanks that Dean Randall gets from students. But for this, they would not have made it through MIT."

**"I know from personal experience how critical alumni support was to making my MIT dream come true."**



KAREN AND RALPH IZZO

# Unrestricted Generosity

Ralph and Karen Izzo say they'll never forget the moment their son Zachary Izzo '17 learned he had been accepted to MIT. "Zach was a nervous wreck as he opened the email," recounts Ralph. "He hit the link and there were those first words: 'We are pleased to congratulate you...?' He jumped out of his chair shouting 'yes!'—he was just euphoric."

For Zach, who knew in the sixth grade that he wanted to study at MIT, the euphoria of that moment never really waned. Karen remembers visiting Zach for the first time on campus after being cautioned by another parent to expect their son to be worn thin from his first month at the Institute. "But there he was with a huge smile on his face, and he said, 'I've found my people.'" For the first time in his life, the Izzos say, Zach was immersed in an environment where his passion and talent for math made him part of the majority rather than the exception.

In gratitude for their son's phenomenal experience at MIT and inspired by the message of the MIT Campaign for a Better World, Karen and Ralph recently made a generous gift to the Institute. Ralph, who is chairman, president, and CEO of Public Service Enterprise Group (PSEG), a New Jersey energy company, and Karen, a retired biologist, chose to make their gift unrestricted, to give MIT the ability to use the funds where they are most needed.



PHOTO: © DOMINICK REUTER

For the Izzos, supporting MIT with a gift was never a question. But deciding exactly how to give back was a family decision. Ralph and Karen discussed it with Zach and "collectively agreed that money is fungible. We decided to trust the Institute to use its best judgment about where the gift would help the most," says Ralph. The flexibility provided by unrestricted funds enables the Institute to quickly respond to critical and evolving needs and pursue bold research directions. Looking forward, Ralph and Karen say they "would be delighted" to have their gift play some part in helping MIT fulfill the promises of the Campaign—whether it's helping to fund student support, basic research, or any number of other essential needs.

Ralph's membership on the Department of Nuclear Science and Engineering Visiting Committee keeps him connected to the MIT campus, as does the lecture he gives every

November in nuclear science and engineering professor Michael Golay's Sustainable Energy class. But the Izzos say they miss the regular family visits to campus. "We loved being there. Just walking the streets and looking at the faces of the students and being a part of that atmosphere makes you smile," says Karen. Regular campus visits aren't out of the question for the future: now a doctoral student in mathematics at Stanford University, Zach's dream job is to one day teach math at MIT, according to his parents.

The Izzos' appreciation for MIT reflects the couple's micro- and macro-experiences with the Institute. "Because of MIT, our son has had four of the happiest years of his life to date and is in a great position to build upon that," says Ralph. "And because of MIT, we have greater confidence that the world will become a better place." —Katy Downey



PHOTO: JARED JARVIS

## The Better World Tour Dives Deeper

A series of events in the coming months will convene alumni and friends to continue the MIT Campaign's celebration of the Institute's community and to dive deeper into MIT's work to build a better world. Hear from MIT leadership, faculty, alumni, and students in these and other locations still to be announced.

# Building on the MIT Experience

For Pappudu Sriram '96 and Rajesh Venkataramani MBA '00, PhD '00, MIT provided the skills and experiences that would lead them into exciting careers. Years later, the MIT community remains a central point of connection in their lives for friendships, shared values, and ever-expanding interests.

The couple, who go by Pop and Raj, were introduced by friends in the MIT South Asian Association of Students. Both grew up in the US, in families that emigrated from South India in the 1960s. Today they reside in London, where Raj is a partner at Goldman Sachs, and Pop, who spent nearly 20 years with the Boston Consulting Group (BCG), is devoting her days to the care of their daughters, ages 4 and 1.

Raj completed his doctorate under the mentorship of Klavs F. Jensen, Warren K. Lewis Professor of Chemical Engineering, and also earned an MBA from MIT Sloan. The combination, he says, has served him incredibly well, from the first “burst” of professional achievement when he drew directly on his PhD research, to professional growth supported by communication and problem-solving skills.

The skills Pop acquired at MIT (and later at Harvard Business School) fueled her success at BCG, where she was made partner. “I loved my time at MIT,” she says. “It was a period of huge growth in many different dimensions.” Her fondest memories include a course from the late Hartley Rogers Jr., math professor, champion rower, and renaissance man; and the challenges and skill-building opportunities she learned as a team leader in the seminal 2.70 (now 2.007) Introduction to Design and Manufacturing class taught by Woodie Flowers SM '68, MEng '71, PhD '73, who is now the Pappalardo Professor Emeritus of Mechanical Engineering. Pop also credits extracurricular activities, like the women’s rowing team and her Kappa Alpha Theta sorority, with cultivating vital skills.

“All my MIT experiences helped me develop a problem-solving mindset that I really enjoyed and was good at, and that segued into my career at BCG.”

To extend MIT education to a new generation, Pop and Raj have created an unrestricted scholarship fund at MIT. “We want MIT to be able to

get the best people without any constraints and provide others the opportunities that we had.”

“Education is the best investment you can make in anybody,” Pop adds. “That’s at the core of our family values.” At the Alumni Leadership Conference she attended in spring 2017, Pop was impressed with MIT’s efforts to build strengths and address critical challenges. “It’s clear that the financial environment for institutions like MIT is increasingly challenging,” she says. Through their scholarship fund, they hope to be part of the solution.

With their daughters, Pop and Raj are enjoying the abundant offerings of London, including museums, cultural institutions, parks, and family-friendly events around the city. They are also active in the MIT Alumni Club of Great Britain, and they helped to host a London-based celebration of the MIT Campaign for a Better World in 2017.

For Pop and Raj, the words “better world” speak to a core MIT quality: what Pop describes as “an intrinsic interest in the world, and in doing things for the good of the planet and other people.” She adds, “I can’t imagine a world without MIT.” —Kris Willcox



PHOTO: JOHN SCRIVENER

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## WE BUILD ON HISTORY.

In 2016, students in the Concourse program studied the history of bookmaking—then constructed a hand-set printing press. Now that press is available in Barker Library to any aspiring Gutenberg in the MIT community. During Independent Activities Period 2018, history professor Anne McCants demonstrated the mechanics to MIT Libraries staff. “One of the values of making something,” says McCants, “is learning that we moderns are not the only clever ones. People in the past were clever too, and they also knew some things we don’t.”



CAMPAIGN FOR A BETTER WORLD