Spectrum

Massachusetts Institute of Technology
Spring 2022

MIT FOR A
BETTER
WORLD

One of the many capital projects undertaken during the Campaign for a Better World was a refurbishment of MIT's landmark Kresge Auditorium. Read about Lord Swraj Paul '52, who supported work on Kresge's 1,200-seat theater, at spectrum.mit.edu.

Look for additional donor stories throughout this issue.

PHOTO: JUSTIN KNIGHT

(↗) READ MORE AT

spectrum.mit.edu

Spring 2022

The MIT Campaign for a Better World raised $6.24 billion—with support from more than 112,000 alumni and friends—to help the people of MIT tackle humanity's urgent global challenges.

Reimagining Campus

Discovery Science

Health of the Planet

Human Health

Innovation and Entrepreneurship

Teaching, Learning, and Living

MIT Spectrum connects friends and supporters of the Massachusetts Institute of Technology to MIT's vision, impact, and exceptional community.

Contact Us
617.253.0800
spectrum@mit.edu

spectrum.mit.edu
betterworld.mit.edu
giving.mit.edu/spectrum

Vice President for Resource Development
Julie A. Lucas

Executive Director of Communications, Events, Donor Relations, and Stewardship
Carrie Johnson

Editor-in-Chief
Tracey Lazos

Managing Editor
Kathryn M. O'Neill

Senior Creative Director
Barbara Malec

Creative Director
Elizabeth Connolly

Design
Stoltze Design

Senior Contributing Designer
Niki Hinkle

Editor
Evanthia Malliris

Digital Marketing Director
Ben Schwartz

Spectrum Online
Stephanie Eich

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

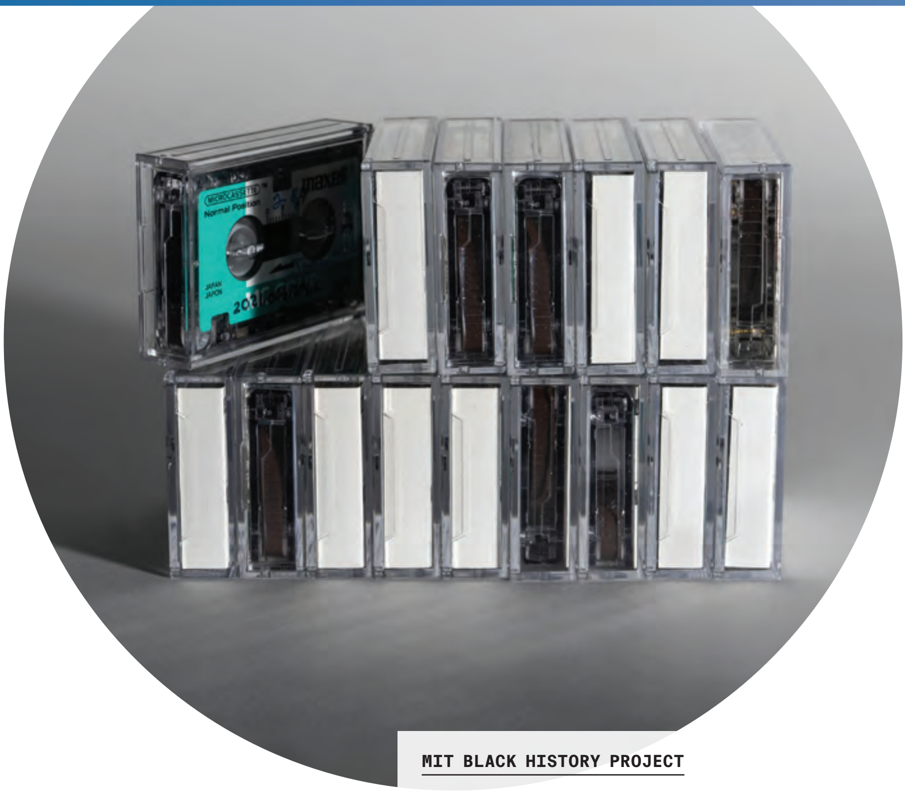
FSC www.fsc.org RECYCLED Made from recycled material FSC® C084277

MIT's Campaign for a Better World spotlighted the bold, pioneering spirit of our community. Overcoming obstacles and seizing opportunities, we have continued to take on new problems and seek fresh solutions to the world's greatest challenges. For this issue of *Spectrum*, we feature ideas, innovations, and discoveries brought to life by the generosity of MIT's extraordinary alumni and friends.

L. Rafael Reif
MIT President

President Reif addresses guests at MIT Better World Miami in March 2018. The Better World Campaign tour stopped in 23 cities around the globe from 2016 to 2020 and made three virtual appearances. Read more at betterworld.edu/engagement.

PHOTO: EILEEN ESCARDA



Conversation Pieces

New MIT Museum in Kendall Square invites exploration and discussion

When the new MIT Museum opens in fall 2022, it will provide public access to the world of science and technology and a window into the cutting-edge research underway at the Institute. Relocated to a central spot in bustling Kendall Square, the new museum will feature 67,000 square feet of galleries, classrooms, a dynamic public makerspace, and a soaring two-story seating area where people can meet and discuss ideas.

The MIT Museum's collection encompasses more than a million objects, prints, rare books, drawings, photographs, films, and holograms that reflect the wide interests of the MIT community from the Institute's founding in 1861 to today. A new gallery, MIT Collects, will highlight many pieces that have never been exhibited before within installations ranging from *Modeling Everything* to *Totally Useless Things*, a collection focused on toys, puzzles, play, and the role of creativity in scientific research.

The museum, made possible partly through the generosity of MIT's donors, will also feature an exhibition called *Essential MIT*. Centered on the process of inquiry and discovery, this exhibition will spotlight ongoing research projects.

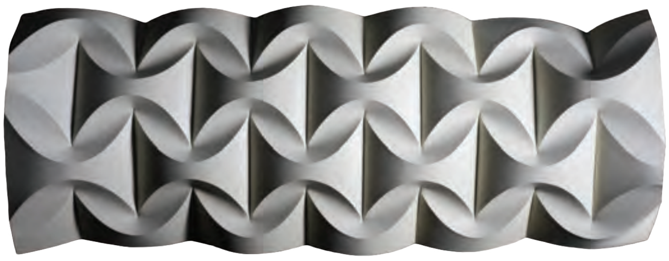
John Durant, the Mark R. Epstein (Class of 1963) Director of the MIT Museum, says museum staff are excited to welcome back visitors. "We are really keen to be a meeting ground between the academic community and the wider community, especially around issues that need a full discussion in public," he says. "So please come join the conversation. That's what we're about."

—Kathryn M. O'Neill

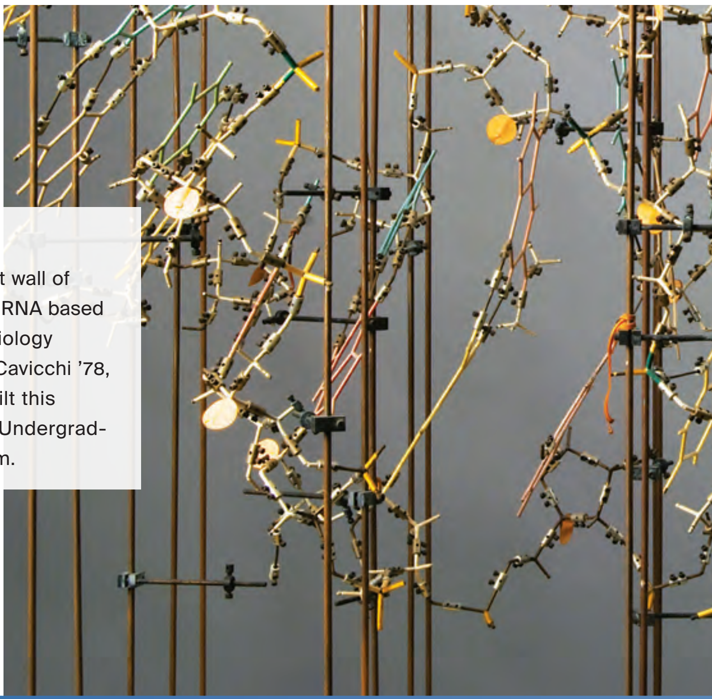
MIT BLACK HISTORY PROJECT

These cassette tapes exhibited at the museum hold some of the more than 200 interviews conducted by Adjunct Professor Emeritus Clarence G. Williams in the 1990s for his book *Technology and the Dream: Reflections on the Black Experience at MIT, 1941–1999*. It is the largest collection of interviews of Black STEM professionals in the world. Williams, who was also special assistant to the president and ombudsman, founded the MIT Black History Project, an ongoing research effort.

DAVID A. HUFFMAN COLLECTION



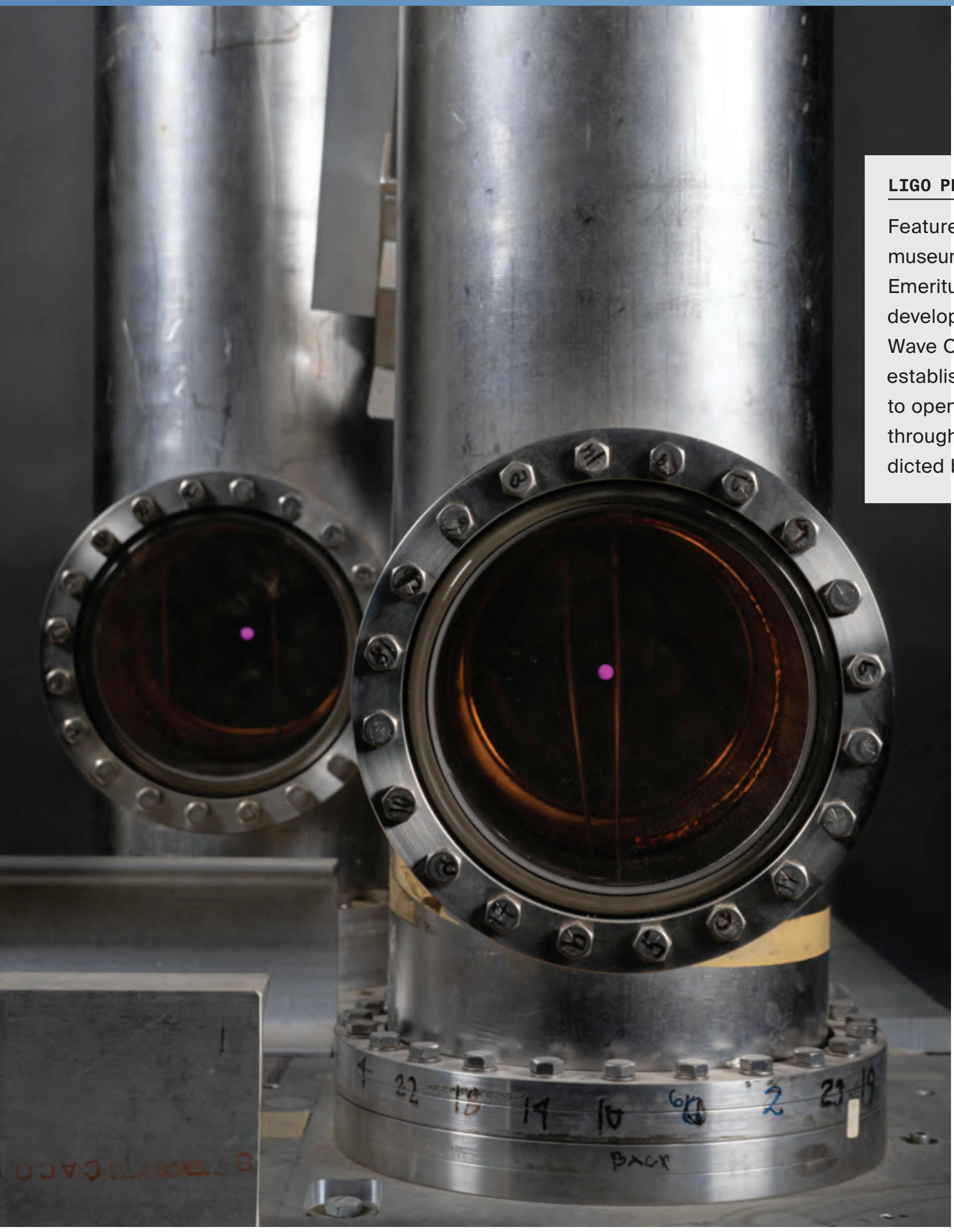
This white vinyl model illustrates some of the folding techniques explored by David A. Huffman ScD '53, a pioneer of computational folding who was an MIT faculty member for 14 years. The MIT Museum's collection includes more than 100 models by Huffman, whose work helped advance lossless compression, a technique used in digital photography.



TRANSFER RNA MODEL

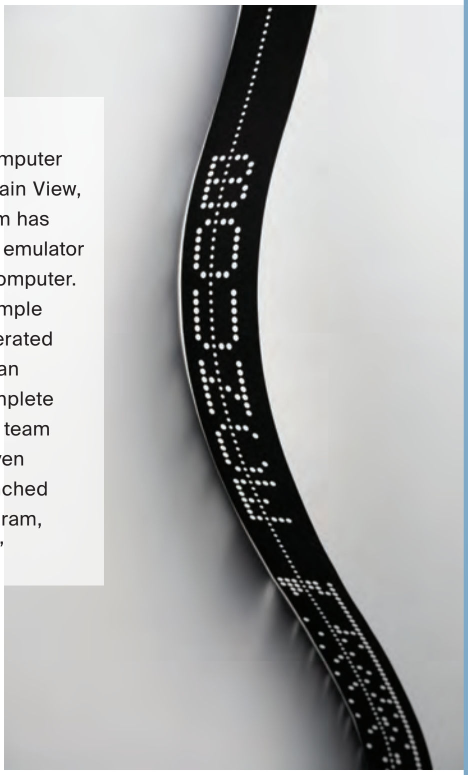
The new museum features an 80-foot wall of models, including this one of transfer RNA based on the pioneering research of MIT biology professor Alexander Rich. Elizabeth Cavicchi '78, SM '80, now an instructor at MIT, built this model for Rich in 1975 as part of an Undergraduate Research Opportunities Program.

PHOTOS: COURTESY OF MIT MUSEUM



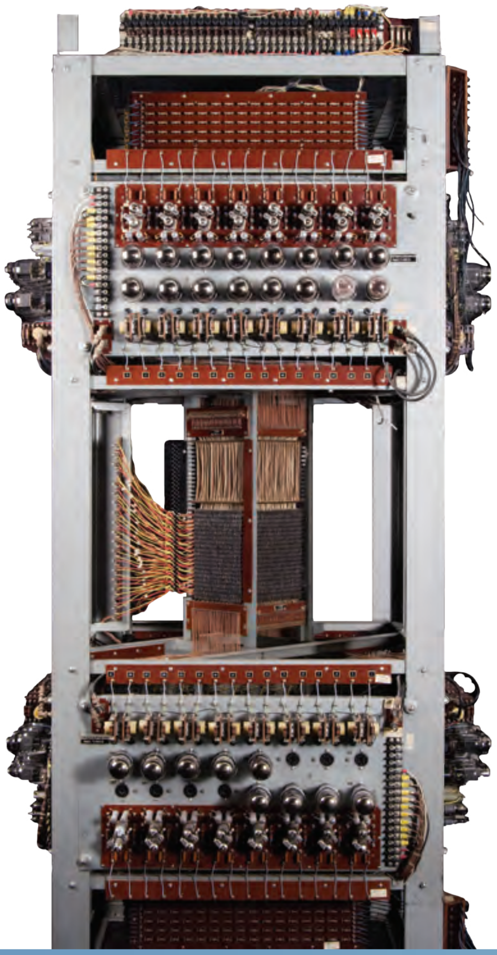
LIGO PROTOTYPE

Featured in the *Essential MIT* exhibition in the new museum is the pioneering prototype that Professor Emeritus Rainer Weiss SB ’55, PhD ’62 and his students developed for the Laser Interferometer Gravitational-Wave Observatory (LIGO). MIT played a key role in establishing LIGO, a large-scale national facility designed to open the field of gravitational-wave astrophysics through the direct detection of gravitational waves predicted by Einstein’s General Theory of Relativity.



BOUNCE PROGRAM

In partnership with the Computer History Museum in Mountain View, California, the MIT Museum has been working to create an emulator of the historic Whirlwind computer. The effort began with a simple 30-line program that generated a bouncing ball effect on an oscilloscope, the only complete program that the museum team knew worked. The team even reverse-engineered a punched paper tape to run the program, which they titled “Bounce.”



WHIRLWIND COMPUTER

This 4K core memory unit is one of several objects on display at the MIT Museum related to the Whirlwind computer. Developed at MIT between 1945 and 1952, Whirlwind was the first digital computer able to operate in real time and one of the first large-scale high-speed computers ever built. The project, which began as a World War II effort to develop a flight simulator, was directed by Jay W. Forrester SM ’45, who was a professor at MIT Sloan.

Electrons appear to flow freely between two sheets of graphene in this image. Pablo Jarillo-Herrero's discovery of the "magic angle" that enables this flow could usher in a new generation of superconductors.

IMAGE: ELLA MARU STUDIO

Key Underpinnings of Scientific Inquiry

Foundations provide crucial support for cutting-edge research

If it takes a village to raise a child, it takes an ecosystem to grow excellence in research. Scientists work long hours pursuing insights, hitting dead ends, and revising roadmaps. Oftentimes, discoveries are made by those whose trajectories were anything but predictable—researchers eager to follow a hunch or a passion without knowing where it might lead. Significant support for such risky research comes from private foundations. At MIT, this kind of funding fills a crucial niche, placing necessary bets on a novel idea, a mid-career pivot, or a promising but unproven young researcher. As the below examples illustrate, the payoff is that science moves forward.

Fuel for a breakthrough

Pablo Jarillo-Herrero likes to encourage his students to take risks. "I ask them to imagine themselves as a scientific Indiana Jones," says Jarillo-Herrero, the Cecil and Ida Green Professor of Physics, referring to the hero of the *Raiders of the Lost Ark* movie franchise. "To think like explorers going into the jungle with a machete, with only a vague idea of where they might end up."

Jarillo-Herrero's own trek has led him to a discovery many think could usher in a new generation of superconductors with potential applications from energy transport to levitating trains to quantum computing. The discovery involves two sheets of graphene—a two-dimensional material consisting of a layer of graphite just one-atom thick—stacked at the so-called "magic angle." That magic angle somehow creates a crystalline lattice that allows electrons to flow freely between the two stacked sheets.

"Electrons are negatively charged and normally repel each other," says Jarillo-Herrero. "We don't usually see this in solids because they have considerable kinetic energy. But in sheets of graphene, set at a certain angle, the kinetic energy drops, and another force, their repulsive interaction energy, becomes more prominent. Then crazy things can happen. We found a system that could be either a superconductor or a different type of insulator, depending on how many electrons we put into that system."

Along with his Indiana Jones spirit, the rising physics star credits critical support from the Gordon and Betty Moore Foundation for fueling his work; the foundation named him an investigator for its Emergent Phenomena in Quantum Systems Initiative in 2014. "I was looking at a funding cliff," he says, noting that his group had a number of grants that were expiring in 2016 and 2017. "But these were also extraordinary years for our group, with so many things just coming into focus. I didn't have the mental bandwidth to write grants at the same time. With the Moore funding, we were able to dedicate all our energies to our research and push the project through to completion."

Jarillo-Herrero is quick to note that other funders, including the National Science Foundation, were also instrumental in his magic angle research. "The Moore funding was less restrictive," he adds. "With it, we could change directions midway, reallocate resources to projects that had suddenly become interesting. The Moore Foundation encouraged and enabled us to take those necessary risks."

PORTRAITS: L. BARRY HETHERINGTON (JARILLO-HERRERO), ALISON GOLD (BOYER), COURTESY SCHMIDT SCIENCE FELLOWS (NGETICH), WEBB CHAPPELL (TISDALE)

Intellectual freedom

For a brief time after birth, a baby's heart cells can repair and regenerate themselves following cardiac injury. As we continue to grow into adults, our hearts lose this capacity. Laurie Boyer wants to know how that happens and if there is a way to harness this process to fix hearts.

"The body has cells, like skin and blood cells, that constantly renew themselves," says Boyer, a professor of biology and biological engineering at MIT. "But the developed heart lacks dedicated stem cells like these other tissues. Instead, cardiac muscle cells stop dividing early after birth, making it difficult to replace damaged cells in response to injury or disease. We hoped that if we could learn how to turn back the developmental clock, we could restore the heart's capacity to replace lost cells."

Boyer spent much of her career studying stem cells and the gene regulatory mechanisms that drive their development. After college, she worked at Integrated Genetics/Genzyme during the day and spent her nights volunteering in the lab of David Housman, the Virginia and D. K. Ludwig Scholar for Cancer Research at MIT. Housman helped steer Boyer to a PhD program at the University of Massachusetts Medical School. She joined the MIT biology faculty in 2007 and received tenure in 2014. She also joined the Department of Biological Engineering.

In 2017, Boyer submitted a proposal to the G. Harold and Leila Y. Mathers Foundation. She'd already compiled an impressive academic record, helping to decipher the role of the epigenome in the cellular decision-making process. She had funding from leading institutions including the National Institutes of Health, but she also hoped to take on new challenges. "I was thinking about the future of our research," she explains. "I wanted to pivot toward projects with translational potential, projects whose success requires new ideas and new developments in technology, but institutional funding doesn't typically afford you the time to do that."

She received a three-year grant that provided her the opportunity to make this pivot. "Foundation funding fueled an exciting new phase of discovery," Boyer says.

"We are now charting the various signals that converge on the heart genome and tell it how to grow and function," says Boyer, who has found a novel connection between a metabolic enzyme and cardiac maturation. "If we can understand the mechanisms that regulate these cell fate transitions, perhaps we can discover new therapies."

Foundation support has helped Laurie Boyer investigate the metabolism of heart cells as pictured here. The contractile structures are marked in green, and the nuclei are magenta.

IMAGE: ALEX AULD

Early career impact

MIT postdoc Gladys Chepkirui Ngetich can't remember a time she didn't love math and physics. An interest in thermofluids and turbomachinery took her to Kenya's Jomo Kenyatta University of Agriculture and Technology, and then to Oxford University in England as a Rhodes Scholar. She wrote her PhD thesis on jet engine coolants.

Ngetich came to the United States and MIT in 2020 as a Schmidt Science Fellow and joined the Space Enabled research group in the MIT Media Lab. The group works to advance justice in Earth's complex systems by using designs inspired and enabled by space research. Ngetich, who was named an International Astronautical Federation "Emerging Space Leader" in 2021, is deeply committed to sustainable development goals, and she has shifted her research from jet engine coolants to environmentally friendly, wax-based propellants for use in rocket launches and in-space propulsion.

"The Schmidt Science Fellowship has given me a special chance to step out of my comfort zone and try a research area very different from my PhD," says Ngetich, who hopes one day to contribute to Kenya's space sector. "This interdisciplinary research has introduced me to a new way of approaching and solving research problems."

Teachers and scholars

Several private foundations provide recognition and stability for young faculty in the sciences. During the Campaign for a Better World, MIT faculty won 64 Sloan Research Fellowships, nine Packard Fellowships, four Cottrell Scholar Awards, and eight Camille Dreyfus Teacher-Scholar Awards.

William Tisdale, a MacVicar Faculty Fellow who directs an experimental research group in the Department of Chemical Engineering, won his Dreyfus award in 2017.

"A big part of getting students excited is by showing them how excited you are," says Tisdale, whose research focuses on advanced spectroscopy techniques and on next-generation semiconductor nanomaterials, including colloidal quantum dots and halide perovskites. His research could lead to major advances in fields as diverse as solar technology, medical imagery, and quantum computing. "I like thinking how these materials might benefit society. But I also love thinking about how things move around at the nanoscale."

The teacher-scholar award, granted by the Camille & Henry Dreyfus Foundation, provided welcome wiggle room for his growing research group. "I used the Dreyfus funding to support exploration of new ideas, many of which became federally funded projects," says Tisdale. "The flexibility of the Dreyfus funding was key for that."

Underrepresented in science

As an experimental nuclear and particle physicist, Associate Professor Lindley Winslow enjoys the challenge of measuring things that are extremely hard to measure. "The motivation comes from trying to discover the smallest building blocks and how they affect the universe we live in," she says.

Much of Winslow's work focuses on neutrinos—subatomic particles that pass by the billions through ordinary matter. In 2016, she and colleagues earned the Breakthrough Prize in Fundamental Physics for work that detected neutrino oscillations for the first time. Today, she is continuing to try to answer some of the most tantalizing questions in contemporary physics: Why does the universe have more matter than antimatter? and What is dark matter made of?


Winslow


Li

Winslow credits good mentorship with helping her to advance her career, which is why in 2018 she established a physics research fellowship program for women with support from the Heising-Simons Foundation. The program includes a workshop on preparing research proposals. "Confidence in your ability to get grants is integral to wanting to stay in the field, and the numbers (of women physicists) are so low that we cannot afford to lose anyone," she says.

Role models

Belinda Li thinks girls and underrepresented minority children need role models in science, technology, engineering, and math (STEM). "There are way too many stereotypes about computer science and technology," says Li, a second-year graduate student at the Computer Science and Artificial Intelligence Lab and a recipient of a Clare Boothe Luce Graduate Fellowship for Women. A program of the Henry Luce Foundation, the multiyear fellowship supports graduate women in STEM. "If they see someone who looks like them in those fields, they're more likely to think they belong there."

Li studies language models and natural language processing, an interest she developed after a year spent working in Facebook's AI Integrity Team, which developed automated detectors for harmful content such as hate speech and misinformation. "I saw the extent to which we rely on language technologies to detect hate speech," says Li, "and I don't think current language models are always up to that task."

Now, Li is going beyond hate speech detection to investigate whether machines actually understand the language they process. "The Clare Boothe Luce Fellowship allows me to pursue my research without having to worry about funding," says Li. "It lends credibility to what I'm doing."

—Ken Shulman

Donor Spotlight

Scott Denmark '75 loved chemistry so much as a child that he sought out a college that would provide the same sense of fun, discovery, and excitement he had felt doing home lab experiments. "At MIT, I found exactly what I dreamed of," he says. "I felt like a kid in candy store."

Today, Denmark is the Reynold C. Fuson Professor of Chemistry at the University of Illinois at Urbana-Champaign. Remembering his time in Course 5 at MIT as "among the most enjoyable, formative, and happiest times of my life," Denmark chose to give back by creating the annual MIT Organic Chemistry Retreat.

Launched in 2018, the all-day, student-run event convenes MIT's organic chemistry graduate students, postdoctoral researchers, undergraduates, and faculty. Through presentations in poster and lecture formats, research groups learn about each other's projects. "I wanted to introduce one element I missed as an undergraduate—a sense of community," Denmark says. "I also want graduate students to take ownership of their graduate experience."

"Communication is paramount to achieving the full potential of science."

Denmark also hopes the event boosts students' presentation skills. "Communication is paramount to achieving the full potential of science to solve real-world problems," he says.

Looking ahead, Denmark says, "I hope that this retreat becomes a marquee event in the MIT calendar for chemistry department students and faculty, a day they look forward to and recall as part of their great memories of MIT."

—Susan Saccoccia

PORTRAITS: M. SCOTT BRAUER (WINSLOW); REGINA FELICE (LI)

‘Go for It’ Attitude Leads to MIT

Grad student studies bacteria, works to make science more inclusive

MIT PhD student Yami Acevedo-Sánchez discovered she enjoyed science by watching television at home in Puerto Rico. While a strong student, encouraged by her mentors and parents to do well, she never imagined a science career would be in her future.

Acevedo-Sánchez is the second member of her extended family—her mother has 17 brothers and sisters; her father has 11—to earn a college degree. She didn’t learn about MIT until she began studying at the University of Puerto Rico, and attending the Institute felt like a very big step.

“I remember my thoughts were, ‘I’m never going to make it there.’ It felt really, really out of reach,” she says. “But I don’t say ‘no’ to myself. I just go for it.”

Today at MIT, Acevedo-Sánchez is pursuing her passion for biology as the recipient of the Bernard S. and Sophie G. Gould Fellowship, working to understand the basic processes that make all the complexity of life possible. “To me, it seems like a puzzle waiting for someone to assemble the pieces,” she says.

Her research focuses on a fundamental question: How do bacterial pathogens hijack a host? By studying how they travel between cells and spur infection, she hopes to discover more about the diseases they cause and potential therapies.

In particular, she is focused on *Listeria monocytogenes*, a widespread bacterium that can cause food poisoning. In high-risk populations, such as pregnant women or immunocompromised individuals, it can spread to the liver and then move through the bloodstream into the rest of the body. *Listeria* infection (listeriosis) has a high mortality rate, killing an estimated 20% to 30% of those infected, according to the US Food and Drug Administration.

Listeria hijacks molecular pathways as it spreads from cell to cell. It typically forces itself into neighboring cells by ramming into cell junctions (spots where cells connect). The force and speed *Listeria* uses to do this is about 0.2–1 microns per second—the equivalent of 50 feet per second if *Listeria* were the size of a submarine, Acevedo-Sánchez says: “It’s very impressive to watch!”

What is the mechanism of this action? Is it random, or programmed and regulated by the bacteria or our cells? Working with assistant professor of biology Rebecca Lamason and others in Lamason’s lab, Acevedo-Sánchez hopes to answer such questions through groundbreaking work that visualizes the cell membrane dynamics as *Listeria* spreads from cell to cell. To do this, the team uses a cellular line with a membrane marker (developed by Lamason) and a confocal microscope, which can capture high-resolution images deep inside cells.

Acevedo-Sánchez is especially interested in exploring how the mechanisms of two proteins, CAV1 and PACSIN2, promote cell-to-cell spread over long distances in a short amount of time.

“These pathogens are constantly interacting with their host,” she says. “By understanding the key players that mediate those interactions from the bacteria side as well as the cell side, we can understand more about the microbiology of the bacteria and our own cell biology.”

Mentoring others

Outside the lab, Acevedo-Sánchez is working to support others like her who have not always believed they could pursue careers in science, technology, engineering, and mathematics. “There is tremendous power in having someone believe in your ability,” she says.

She has served as a mentor for the MIT Summer Research Program in Biology and supported first-year biology graduate students through the BioPals Program. Acevedo-Sánchez has also presented her work to middle school students around the world through the video series MIT Abstracts.

“Anyone can be a scientist, regardless of their background,” says Acevedo-Sánchez, who also has served as a graduate diversity ambassador at MIT. “You just need three things: be curious about the world that surrounds you, be willing to ask questions, and do the work yourself. Work smart and hard.”

—Pamela Ferdinand

Pamela Ferdinand is a 2003–2004 MIT Knight Science Journalism Fellow.

Yami Acevedo-Sánchez researches *Listeria monocytogenes*, a widespread bacterium that can cause food poisoning.

PHOTO: KEN RICHARDSON

“Anyone can be a scientist,” says Acevedo-Sánchez. “You just need three things: be curious about the world that surrounds you, be willing to ask questions, and do the work yourself.”

Math Program = A Plus for Youth

PRIMES mentoring helps high schoolers advance in research

In late 2020, three researchers working in an area of math called combinatorics wrote a paper proving “a Stembridge-type equality for skew dual stable Grothendieck polynomials.” Relatively few people on the planet know what that means—and co-author Jakin Ng ’25 admits she wasn’t one of them when she dove into the project. “The first time I looked at it, I was like, ‘I don’t know how I’m ever going to be able to understand this,’” she recalls.

At that time, Ng and her research partners, Fiona Abney-McPeek and Serena An, were high school students participating in the MIT Mathematics Department’s yearlong Program for Research in Mathematics, Engineering, and Science (PRIMES). Now they’ve submitted their paper for publication, and Ng is a first-year student at MIT in Course 18-C Mathematics with Computer Science. An is slated to enroll next year, and Abney-McPeek is at Harvard.

Adela (YiYu) Zhang ’18, left, mentored Jakin Ng ’25 in MIT’s Program for Research in Mathematics, Engineering, and Science.

PHOTO: KEN RICHARDSON

PRIMES, Ng says, gave her “a taste of what professional mathematicians do—instead of just learning about results other people have already achieved, actually creating new knowledge.”

PRIMES pairs high schoolers with MIT graduate students and

Donor Spotlight

“MIT taught me not to be afraid of a big challenge.”

Kathleen Octavio SM ’77, PhD ’86 has tackled complex problems as a physics major at Clark University, an MIT graduate student in environmental systems and civil engineering, and throughout her engineering career. Today, she is helping address complex, human problems through her support of MIT neuroscience research. “MIT taught me not to be afraid of a big challenge,” she says.

Her motivations are personal: “My husband, Miguel, was hit by a car while we were biking and suffered a serious brain injury.” She and Miguel, a noted physicist, met as undergraduates at Clark. After completing their doctorates at MIT and Harvard, respectively, they spent 35 years in Miguel’s native Venezuela before moving to Florida.

Since Miguel’s life-altering accident, Kathy has learned about, and supported, MIT’s innovative research on brain injury and the aging brain, including gifts to the Neuro-degenerative Disorders and Neurotechnology Funds at the McGovern Institute for Brain Research and to the Aging Brain Initiative and Innovation Funds at The Picower Institute for Learning and Memory. “I’m interested in the whole value chain, from bold new ideas to clinical studies to the latest medical devices. The work they are doing is fascinating,” she says, and will build a foundation for discovery. “I hope that my contributions will help, in some small way, to find solutions that can help other individuals and families in the future.”

—Kris Willcox

postdocs to investigate unsolved problems. Founded in 2010 by math professor Pavel Etingof and lecturer Slava Gerovitch PhD '99, it has expanded into several sub-programs, all free to students. PRIMES-USA attracts some of the most advanced students nationwide, while PRIMES Circle and MathROOTS are designed to reach talented kids with less previous exposure to higher math. All of the program's offerings aim to open the world of mathematics to more people, particularly those underrepresented in the field.

Group projects are relatively new for PRIMES-USA, but Ng was glad to be part of a trio so each student could build on the others' insights. She, Abney-McPeek, and An connected often and had weekly video check-ins with their mentor, MIT PhD candidate Adela (YiYu) Zhang '18.

Zhang provided the high schoolers with background reading on Grothendieck polynomials—the symmetries of which can reveal information about a mathematically important class of geometric objects called Grassmannians—and a roadmap to help them get started. In Ng's words, "Adela was able to zoom out and give us the macroscopic view of what we should be working on."

Zhang says her top priority was to help her mentees build the skills and habits all research mathematicians need, such as "being comfortable with getting stuck but still not giving up."

These are lessons Zhang says she feels she is still learning herself. As a young student in Shanghai, China, she was attracted to math by the beauty of famous theorems, but in her day-to-day research she has had to come to grips with slow progress. She knows what it's like to feel a bit overwhelmed. "When I started mentoring Jakin's group, I was just starting to work on my own project for the first time in grad school. So, I can fully sympathize with what it feels like," she says.

There are successes as well as setbacks. Zhang recalls that Ng spent weeks slogging through examples of an unfamiliar technique called constructing bijections before finally getting the hang of it. "She proved something using this technique, which I found really impressive," Zhang says. "I was proud of her."

Ask Ng if there were moments during the year when she thought her team might never get anywhere, and she laughs. "Basically, the whole time except for the end. I think that's the point. That's how research goes. You have a small victory, you celebrate it, and then you're back to not knowing what's going on."

Connecting with a community

Both Ng and Zhang say that connecting with others through math has made their research pursuits more rewarding. As an undergraduate at MIT, says Zhang, "I felt very lonely because there weren't many women doing higher math." She persevered thanks to encouragement from a female postdoc who supervised her in the Undergraduate Research Opportunities Program (UROP). Zhang went on to serve in turn as a mentor for UROP as well as for PRIMES. The program recognized her ongoing work in 2021 by awarding her a George Lusztig Mentorship.

Ng started building her own math support network while growing up in Ithaca, New York, attending math camps and leading her high school's Science Olympiad and math competition teams. She's met some of her closest friends, including her MIT roommate, through such activities. "A lot of what kept me interested in math was having that community," she says.

Whatever the future holds for Ng, she says she expects math or its applications will play some part in her profession. Meanwhile, she is enjoying a variety of creative activities at MIT, including origami and music. She says PRIMES helped her see that creativity is vital to research. "You're venturing into territory that no one has ever really studied before," she says. "You have to think of new ways to look at something. Otherwise, it's already been done."

—Nicole Estvanik Taylor

Donor Spotlight

"We wanted to start supporting future physics superstars during our lifetime."

Art Peskoff '56, SM '58, PhD '60 and his wife, **Fran**, were at Art's 50th Reunion when they made a key decision. "We don't have children, and we wanted to leave our estate to a charity working to better the world," Fran says. "Attending reunion events, we saw that MIT was already changing the world. We chose MIT as the beneficiary of our bequest."

The Peskoffs' bequest will support fellowships for first-year graduate students in MIT's Department of Physics, where Art did his dissertation in plasma physics. "Given my abiding interest in plasma physics," says Art, "I am especially excited about the work now being done at MIT in plasma fusion."

He and Fran, who majored in math at the University of Southern California, met while working at TRW Inc. Art was a physicist, and Fran was a computer programmer. Later, the pair turned to new ventures, including real estate. Art became an adjunct professor of physiology and biomathematics at the University of California, Los Angeles (UCLA), and Fran earned her MBA at UCLA and founded a company that developed a desktop publishing program for children.

In honor of Art's 60th Reunion, the couple instituted the Frances and Arthur Peskoff Physics Fellowship Fund, which has already awarded fellowships to five students. "We wanted to start supporting future physics superstars during our lifetime," says Fran.

The couple also supports MIT's online physics courses, which educate students worldwide. Art recently took MIT's online courses in quantum physics and says, "I learned a lot about recent discoveries." —Susan Saccoccia

Urban Adaptation to Climate Change

Leventhal Center explores how communities can weather relocation

In a remote village high in the mountains of Tajikistan, local women showed MIT architecture professor Sheila Kennedy enormous boulders sitting in a grassy field. "These absolutely huge boulders had bounced down from 16,000-foot mountains, hit the river, and then bounced up like marbles and landed in this garden," Kennedy recalls. This was no accident. Climate change has reduced the snowpack keeping the mountains stable, leading to increasingly dangerous avalanches. In the spring, melting snow leads to flooding from below.

"These are tangible threats," Kennedy says. "And it was profoundly moving to see the present impact that these multi-hazardous climate change challenges bring to these people."

She was in Tajikistan in 2019 along with a colleague, emeritus landscape architecture professor Jim Wescoat, and a group of MIT graduate students to help design a radical response to the village's problems: moving the entire community 300 meters *higher* into the mountains, to a stable plateau where they would be protected from the perils of the changing climate. The ambitious undertaking is a collaboration between the nonprofit development organization Aga Khan Agency for Habitat (AKAH); Kennedy's firm, Kennedy & Violich Architecture; and MIT's Aga Kahn Program for Islamic Architecture. The goal is to provide a replicable new model for how communities can voluntarily relocate in response to climate change.

The project has been overseen and coordinated at MIT by the Norman B. Leventhal Center for Advanced Urbanism (LCAU), a multidisciplinary center in the School of Architecture and Planning (SA+P) focused on applying design to large-scale urban challenges.

The Tajikistan project was one of three case studies LCAU presented as part of *Moving Together*, an exhibition at the 2021 Venice Architecture Biennale, which was curated by Hashim Sarkis, dean of SA+P. The project addressed the issues of the 150 million people worldwide who will be forced to relocate due to climate change in the next three decades. "It's a particularly challenging topic because relocation is usually the last resort, and it's often implemented poorly," says Wescoat, former co-director of LCAU.

The projects included in *Moving Together* examined how to plan and implement such relocations equitably and proactively rather than reacting as climate refugees flee their homes. In addition to the Tajikistan project led by Kennedy and Wescoat, the exhibit also included an analysis led by architecture associate professor Miho Mazereeuw on efforts to aid a community in a Puerto Rico flood zone and an examination by urban planning professor Janelle Knox-Hayes of attempts to relocate a vulnerable indigenous community in Louisiana.

An MIT team explores the mountains of Tajikistan in 2019 while working with a local village on a plan to move to safer ground.

PHOTO: COURTESY OF KVA

Mountain move in Tajikistan

For the Tajikistan project, Kennedy and Wescoat led a two semester–long course that included a 2019 trip to the Pamir Mountain village with scientists and planners from AKAH, including Kira Intrator MCP '12. "Our role was to expose students to this challenging technical planning and design

> "Climate adaptation can either exacerbate existing inequalities or provide new opportunities," Knox-Hayes says.

problem and bring a series of design options forward that would allow the people of the village to retain their autonomy," Kennedy says. The MIT team used AKAH's drone imagery (analyzed by doctoral student Dorothy Tang) to map the plateau, analyzed sunlight exposure, and assessed existing water and vegetation to determine the most efficient placement of homes and farms.

Working with community members, the team developed an original method of insulating houses with sheep's wool, which the village had in abundance. "The biggest challenge was to shift everyone's mindset from an all-or-nothing point of view and create a design that would be actionable and attainable," says Kennedy.

The project includes a proposal to use gravity to siphon water from higher altitudes down to the valley and keep it under pressure to rise to the village, rather than the more costly alternative of pumping water from the river. Wescoat used his background in water resources to estimate the village's domestic and agricultural water requirements. While the project was put on hold due to the pandemic, LCAU hopes to help AKAH and officials in Tajikistan implement it in the coming year. "We all feel a profound commitment to this project and community to take it to the next steps," Kennedy says.

MIT team members meet with residents of a village in Tajikistan to discuss relocation plans.

PHOTO: COURTESY OF DOROTHY TANG

Flood zone in Puerto Rico

In Puerto Rico, Mazereeuw analyzed an unusual effort to relocate a community along El Caño Martín Peña, a canal on the outskirts of San Juan that has become a flood zone, especially during hurricanes. "There are not many options for communities to move together," Mazereeuw says, noting that US relocation processes typically center on moving individuals. "The social networks we really need during a crisis are broken up."

As an alternative, a local public development corporation called Proyecto ENLACE developed a plan to relocate some 1,000 families to make room for an ecologically sustainable expansion of the channel to mitigate flooding. "They created a committee to guide the whole process for residents to move into new housing or find existing housing within the neighborhood," says research scientist Larisa Ovalles SM '16, who interviewed residents along with Mazereeuw and urban studies doctoral candidate and LCAU doctoral fellow Lizzie Yarina MA '16, MCP '16 to assess the project. "So, they're made aware they're in a high-risk situation, but also given options and resources, rather than just: 'Here's some money, and you figure it out.'"

The project included mental health counseling to address the emotional impact of leaving family land. In addition, ENLACE worked with a nonprofit land trust to ensure residents would retain ownership stakes in the land. "There is a history of forced relocation in Puerto Rico," says Ovalles. "This way they know it's not something that can be taken away from them. The residents are part of the entire process from the beginning." So far, more than 600 families have been relocated, and the US Army Corps of Engineers has begun work on the canal infrastructure.

Working with communities

Despite these success stories, moving people from their homes always raises issues of power and trust. For her part in the *Moving Together* project, Knox-Hayes and her students analyzed the difficulties faced by the members of Isle de Jean Charles Biloxi-Chitimacha-Choctaw Tribe displaced by climate change in Louisiana.

The residents of the Isle de Jean Charles have been struggling with the effects of sea-level rise, exacerbated by canals built for the oil industry; much of their land has been lost. Yet, attempts to resettle to the mainland have been complicated by lack of federal tribal recognition and by state bureaucracy. "There has been a lack of understanding from state and federal authorities about the nature of the tribes and their identities that makes working in a way that is culturally sensitive and appropriate more challenging," Knox-Hayes says.

Donor Spotlight

Ask **Bill Vanderson '99, MNG '00** why he and his wife, **Christina Gehrke '99**, support the MIT Energy Initiative (MITEI), and he'll say it's because MITEI is working to meet global energy needs while mitigating climate change.

"It's very important to put resources toward the science of overcoming climate change," says Vanderson, a development lead at Hudson River Trading. "This is a super-important problem for humanity. We all need to do our part to help."

As part of the annual MIT Alumni Association 24-Hour Challenge this spring, Vanderson and Gehrke matched gifts made to MITEI dollar for dollar. "MIT is among a handful of universities in the world at the forefront of addressing challenges presented by climate change," Vanderson says.

"We all need to do our part to help."

"You think about solar cells, about fusion: MIT is ahead in a lot of those areas. There's an excitement to that."

This was the second year they've issued a matching challenge on behalf of MITEI; also, they served as class challengers during the MIT 24-Hour Challenge on the occasion of their 20th Reunion in 2019. In addition, the couple support the MIT Refugee Hub, an effort to develop global education programs for underserved communities.

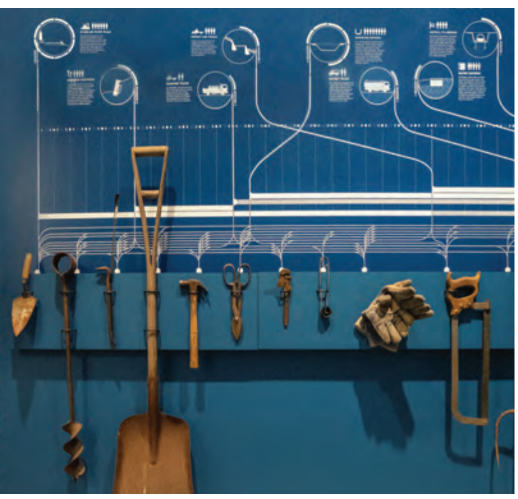
The Institute is close to their hearts. "MIT has given us this great group of friends," says Vanderson, noting that he and his wife met at Baker House and still have 30 to 40 friends from that era. "MIT has given us a lot." —Mark Sullivan

In response to such challenges, Knox-Hayes led efforts this summer for LCAU to develop an Equitable Resilience Framework (ERF) as part of the MIT Climate Grand Challenges Initiative, putting together a plan for community adaptation planning that goes well beyond the usual cost-benefit analysis, taking into account social and racial inequities. “Climate adaptation can either exacerbate existing inequalities or provide new opportunities for more equitable transformations,” she says.

The ERF proposal seeks to pilot the framework with the City of Boston to develop specific adaptation plans for communities vulnerable to climate impacts. “The kind of losses we’re seeing in the Gulf of Mexico now are going to happen in the Northeast in a matter of decades,” Knox-Hayes says. “There’s a critical opportunity to learn from what’s happening in other parts of the country.”

Farther afield, LCAU is reaching out globally to cities where climate change has led to loss of land, food insecurity, and other issues. Most recently, it has begun work with the World Food Program to look at issues around climate and migration. “We are in a climate crisis right now, and it’s one of the biggest challenges cities face,” says Sarah Williams MCP ’05, director of the LCAU and the Norman B. and Muriel Leventhal Associate Professor of Advanced Urbanism. “I hope we can be a hub for how cities can address this issue, from Boston to Tajikistan.”

—Michael Blanding



Moving Together, an exhibition at the 2021 Venice Architecture Biennale, featured three projects from the Leventhal Center for Advanced Urbanism.

IMAGE: COURTESY OF KVA

Donor Spotlight

Climate Grand Challenges Initiative “will move us forward in learning and action.”

Stone Edge Farm Estate Vineyards & Winery in Sonoma Valley, California, produces fine, organically grown wines. It is also a model of energy independence, thanks to a microgrid designed by a postdoctoral fellow from MIT.

Jorge Elizondo Martinez PhD ’16 installed the microgrid in 2014. Since then, its ongoing expansion has drawn 67 interns from 14 universities.

“Our microgrid generates and stores electricity from the sun,” says **John (“Mac”) McQuown**, founding owner of Stone Edge Farm. “We operate with a carbon footprint well below zero.”

When utilities suspended service during California’s 2019 wildfires, the microgrid kept Stone Edge Farm going, says Mac. “We were one of the few businesses in Sonoma Valley that still functioned normally during the shutdown.”

Now, with his gift to help launch the MIT Climate Grand Challenges, McQuown is turning to MIT for environmentally sound energy solutions that are applicable on a global scale.

The Climate Grand Challenges is engaging researchers across MIT in developing energy solutions that reduce the world’s carbon footprint. Faculty from MIT’s five schools and its Schwarzman College of Computing will select and fund five multiyear projects with the potential for rapid, large-scale adoption and impact.

Among its faculty leaders is Associate Provost and Japan Steel Industry Professor Richard K. Lester PhD ’80, who introduced Martinez to McQuown.

“I’m betting on MIT,” says McQuown, who helped pioneer the first equity index funds during his early career at Wells Fargo and later founded several financial services companies. “This initiative will move us forward in both learning and action.”

—Susan Saccoccia

Donor Spotlight

“We don’t have any choice but to get it right.”

“Human beings must organize ourselves better and faster if we want to keep global warming under one-and-a-half degrees,” says entrepreneur, investor, and climate activist **Michael Sonnenfeldt ’77, SM ’78**. Sonnenfeldt, who is founder and chairman of the investment network TIGER 21, believes that “MIT has an absolutely unique standing from which to make an extraordinary impact” in climate action. He is particularly interested in the work of the MIT Sloan Sustainability Initiative and its Climate Pathways Project, which he supports as a donor and as cochair.

“I’ve been an investor and deeply involved in alternative energy for 30 years, but for the last 15 years I have been all climate, all the time.” The Climate Pathways Project, which works to accelerate the adoption of evidence-based climate policy, is an opportunity to introduce modeling tools such as En-ROADS to key decision makers and to bring MIT’s credibility to climate discussions, he says. Sonnenfeldt is also proud to be adding talented Sloan graduates to the sustainable investing team of his company MUUS Climate Partners.

“Being an MIT undergrad and a Sloan graduate are defining attributes of my life,” says Sonnenfeldt, who encourages others to join him in championing MIT’s climate action. “The decisions we make in the next decade will be among the most consequential in human history, and we don’t have any choice but to get it right.” —Kris Willcox

Lessons from Space for Handling Waste

AeroAstro team applies systems thinking and analysis to vital recycling issue

Siddiqi

de Weck

At first, it might seem odd: Why would two experts in the space program take on a project that relates to, of all things, farm animal waste? But when you think about it, the notion makes sense. Olivier de Weck SM ’99, PhD ’01, the Apollo Program Professor of astronautics and engineering systems, and Afreen Siddiqi ’99, SM ’01, PhD ’06, a research scientist in MIT’s Department of Aeronautics and Astronautics (AeroAstro), work on closed life-support systems, such as crew quarters on the International Space Station and proposed habitats on Mars, which need to provide clean air and water and recycle all wastes. Why not apply the expertise they’ve gained to managing animal waste from small farms on Earth?

The environmental stakes are considerable: throughout the globe, there are more than 475 million farms smaller than five acres, and they generate hundreds of millions of tons of manure each year. Siddiqi and de Weck are now studying the thousands of small farms in Brazil that line the Paraná River, which flows into the Itaipu Dam, the world’s second-largest hydroelectric power plant. Animal wastes that wash into the river seriously degrade water quality and promote algal blooms that can impede efficient power generation.

With funding from MIT’s Abdul Latif Jameel Water and Food Systems Lab (J-WAFS) and consultation from Brazilian colleagues, de Weck and Siddiqi embarked on a project in 2021 aimed at devising economically viable strategies for preventing farm waste from entering the Paraná by turning it into valuable byproducts—solid fertilizer pellets and biomethane. The latter can be used for cooking and heating or to generate electricity, and it can also be converted into compressed natural gas, a transportation fuel.

Applying a method they use in their space research, the MIT duo are addressing this challenge from a “systems perspective,” which enables them to assess how the many factors involved—water, energy, agriculture, transportation, and the environment—are interdependent, and what tradeoffs might have to be taken into account. “We want to use our knowledge of these connections to come up with new solutions that we might otherwise miss if we just looked at one part of the system,” Siddiqi explains.

To support this project, de Weck enlisted students in his Multidisciplinary System Design Optimization class to analyze various options for handling farm waste, including processing it onsite with small-scale biodigesters or transporting it to regional processing facilities by trucks. This approach has demonstrated that there is no single best solution, de Weck explains. In choosing between a centralized or decentralized approach, “the optimal solution will be dictated by geography, depending on the size of the farms, the average distances between them, and the quality of roads.”

It’s a complex challenge, so the team has developed a sophisticated model that weighs the costs of installing biodigesters and transporting wastes against the value of the electricity and natural gas produced. “We’re modeling not just the flow of wastes and biomethane, but also the flow of money,” de Weck says. Based on current technology and prices, waste recovery systems would not be self-sustaining, but that could change with incentives that monetize the benefits of reduced water pollution—especially when lowered operating and maintenance costs at the hydropower plant are factored in. This finding emphasizes the applicability of their research to policy makers in addition to the farmers themselves.

The MIT team presented its preliminary findings at the December 2021 meeting of the American Geophysical Union, a prime gathering spot for Earth and space scientists from all over the world. The researchers plan to carry out site visits in the Paraná region in 2022 to gather more data and then share their model with Brazilian decision makers. They also plan to study farms in New England.

“Our aim is to have a tool that is applicable to agricultural areas throughout the world, so long as you provide it with the right data,” Siddiqi says. “Although this tool is presently focused on animal-waste generation and recovery, the same approach could be applied to other kinds of waste streams and other kinds of problems.” —Steve Nadis

Steve Nadis is a 1997–1998 MIT Knight Science Journalism Fellow.

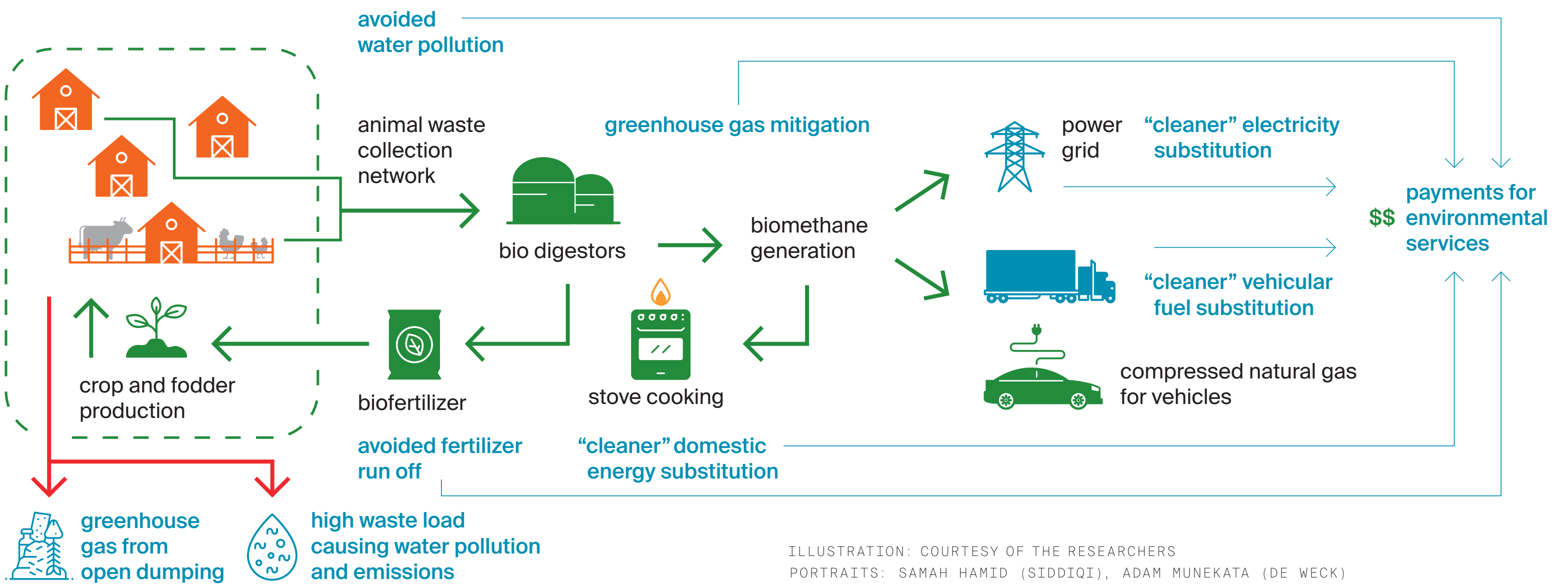


ILLUSTRATION: COURTESY OF THE RESEARCHERS
PORTRAITS: SAMAH HAMID (SIDDIQI), ADAM MUNEKATA (DE WECK)

Innovations Centered on Developing World

Tata Center marks 10 years of sustained impact

Success has many parents, perhaps none more than in academia, where collaboration and idea sharing is built into the DNA of most endeavors. So perhaps it's not surprising that when the Global Energy Alliance for People and Planet (GEAPP) was unveiled at the 2021 United Nations Climate Change Conference, one thread in its lineage could be traced back to MIT: the MIT Tata Center for Technology and Design, part of the MIT Energy Initiative (MITEI).

Established in 2012 to bring rich technical talent and experience to bear on the persistent and emerging challenges of the developing world, particularly India, the Tata Center has spent the past decade supporting MIT faculty and graduate students who do groundbreaking work in a myriad of sectors—always with the goal of improving quality of life for billions of people in developing nations.

According to Tata Center founding director Robert Stoner, one endeavor, centered on rural electrification planning and design, ultimately led to a partnership with the Rockefeller Foundation to create the Global Commission to End Energy Poverty. The commission brings together utilities, off-grid electrification companies, multilateral development banks, academics, and others to find ways to provide power to the 800 million people who lack it. Stoner, who is also the deputy director for science and technology at MITEI and the secretary of the commission, says the commission provided the intellectual underpinnings for the GEAPP, a philanthropic program subsequently launched by the Rockefeller Foundation that has so far attracted pledges of $1.5 billion to address energy access, carbon emissions, and jobs in energy-poor countries.

This extraordinary success story is hardly a first for the Tata Center, which was founded with support from the Tata Trusts, one of India's oldest philanthropic organizations. Over the past 10 years, Tata Center–funded researchers have developed dozens of products and services, produced influential policy papers, and launched numerous new businesses and nonprofits serving the developing world, with innovations related to energy access, water, housing, health care, the environment, and agriculture.

An Indian woman carries a solar panel developed by Khethworks, the first startup to emerge from the Tata Center.

IMAGE: COURTESY OF KHETHWORKS

"The Tata Center has been about teaching people in a novel way to engage with problems and bring technology to bear," Stoner says. The center's methodology includes providing multiyear funding for lab, field, and policy research; collaborating with governments, companies, nongovernmental organizations, and universities; and training graduate students to mold solutions to the market conditions and community needs of developing countries.

A hallmark of the program has always been to provide support for Tata Fellows, a select group of MIT students who commit at least 10 weeks a year to working in India and other developing countries over the course of their graduate careers. Research with real-world application is the key emphasis, Stoner says, noting that the center launched its Translational Research Program in 2017 to help move promising technologies from lab to market.

Here are just a few examples of the challenges the Tata Center has addressed over the past decade and the solutions that have emerged.

Sustainable agriculture

During trips to India as Tata Fellows in 2013, Katie Taylor SM '15 and Kevin Simon PhD '19 learned firsthand that many farmers in rural areas have limited access to electricity, making it difficult for them to pump water out of the ground to grow crops outside of monsoon season.

To address this challenge, Taylor and Simon expanded on a pump design project they began in their 2.760 Global Engineering class taught by mechanical engineering associate professor Amos Winter SM '05, PhD '11. Over time, the pair worked with smallholder farmers in India and were ultimately able to develop a groundwater pump that runs on the most reliable, abundant resource available to farmers during dry months: the sun.

They went on to cofound Khethworks, the first startup to emerge from the Tata Center, to commercialize the technology.

Today Khethworks' portable, solar-powered, water pump is enabling year-round irrigation, cultivation, and income generation for many smallholder farmers in eastern India, Nepal, and Malawi. In 2015, the work was recognized by India's Prime Minister Narendra Modi, who said, "MIT Tata Center's Khethworks is changing the lives of small farmers."

Pollution reduction

India has millions of small farms cultivating rice, wheat, sugarcane, and other staple crops. Twice a year, when the harvest is in, farmers burn the remaining stalks and other waste, releasing carbon dioxide and particulate matter into the atmosphere, profoundly degrading the air quality in downwind cities.

As a Tata Fellow, Kevin Kung SM '13, PhD '17 began working on addressing this waste problem with Tata Center faculty member Ahmed Ghoniem, the Ronald C. Crane Professor of mechanical engineering. Over time, the researchers were able to design, optimize, and implement a low-cost and robust system that can convert agricultural waste into charcoal, fertilizer, and activated carbon, which can be used in water filtration systems.

Kung cofounded a company, Takachar, to commercialize the technology. Takachar's machine uses a roasting process called torrefaction to densify biomass, making it transportable and increasing its shelf life.

In 2021, Takachar won the first-ever Earthshot Prize in the clean air category, a £1 million prize awarded by the Royal Foundation of the Duke and Duchess of Cambridge. At scale, Takachar estimates its product could reduce carbon dioxide-equivalent emissions by 700 million tons per year.

Better living conditions

Rapid urban growth has led to an increase in overcrowded informal settlements—particularly in and around the major cities of the developing world. A lack of infrastructure and open spaces as well as unsafe structures make such areas difficult places to live and work.

Ana Cristina Vargas SM '14 began addressing this challenge as a Tata Fellow. She developed a pilot project in Boston's Jamaica Plain neighborhood and later held several workshops in Mumbai, India. Her strategy was to encourage residents—particularly children—to take ownership of the public spaces in their communities and improve them.

Having developed a replicable and sustainable methodology for transforming spaces, Vargas went on to found Trazando Espacios (Tracing Spaces), a Venezuelan nonprofit that develops training programs aimed at children between the ages of 9 and 13 who live in communities with the potential for transformation. In 2015, Vargas received the Dubai International Award for Best Practices in recognition of her innovative work on public spaces around the globe.

Electricity access

Over 3 billion people around the world have unreliable access to electricity, and close to 800 million people lack access altogether. The problem is especially acute in rural communities in sub-Saharan Africa and South Asia, which can be difficult and expensive to reach with grid power. Tackling this issue with cutting-edge research combining novel system optimization techniques and regulation has enabled the Tata Center to become a world leader in rural electrification planning and design.

Over six years, the Tata team, including eight students led by Stoner and senior lecturer Ignacio Pérez-Arriaga SM '78, PhD '81, focused on the idea of using off-grid technologies efficiently to provide electricity in rural areas where the grid was deemed to be unaffordable. Such technologies, including solar microgrids and isolated systems, can be a better match to the needs of rural consumers.

To identify the most cost-effective combination of grid and off-grid connections over very large areas, Tata researchers developed a computational model known as the Reference Electrification Model. Today this software tool is used throughout the developing world to create affordable universal electrification programs.

Water scarcity

When Tata Fellow Maher Damak SM '15, PhD '18 began work on his doctoral research with professor of mechanical engineering and Tata Center faculty member Kripa Varanasi SM '02, PhD '04, their goal was to improve the efficiency of fog-harvesting systems like the ones used in some arid coastal regions as a source of potable water; they also considered applying such systems to capture water from industrial cooling towers.

Damak and Varanasi found that vapor collection could be made much more efficient by applying a charge to the tiny droplets that make up fog and then collecting them on an oppositely charged wire mesh. The project ultimately led them to cofound Infinite Cooling to capture and reuse water evaporating from cooling towers at power plants, reducing water consumption for some plants by more than 20%. The technology was successfully piloted at MIT's Central Utility Plant and is now being deployed commercially around the world.

Since thermoelectric power generation accounts for 39% of all freshwater withdrawals in the United States alone, the company has the potential to save billions of gallons of water for agriculture, sanitation, or human consumption.

The Reference Electrification Model developed with the support of the Tata Center has been used to inform electrification plans for rural areas around the world, including Rwanda.

PHOTO: COURTESY OF TATA CENTER

Above: Graduate student David Lussier '81, SM '82 and Frank Durgin, associate director of the tunnel from 1966 to 1992, in the original facility.

PHOTO: COURTESY OF THE MIT DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

Left: Former MIT postdoc Alejandra Uranga PhD '11 and Professor Mark Drela experience the new wind tunnel.

PHOTO: ADAM GLANZMAN

We're Big Fans!

8 things to know about the new Wright Brothers Wind Tunnel

What do World War II aircraft, subway station entrances, Olympic ski apparel, and thousands of MIT students have in common? They've all taken a spin, in some form, in the Wright Brothers Wind Tunnel, which for eight decades has been a force for education and experimentation in aerospace, architectural, vehicular, and other engineering systems at MIT. In 2019, the vintage tunnel was demolished to make way for a new facility, funded in part by a gift from The Boeing Company and from Becky Samberg and the late Arthur (Art) Samberg '62. The tunnel will open fully to students, faculty, and industry collaborators later in 2022.

Boeing and MIT share a long history. On July 4, 1915, William E. Boeing took his first seaplane flight with George C. Westervelt, a graduate of MIT's first-in-the-nation aeronautics course. Boeing and Westervelt would go on to build their own plane, the B&W, and found the Pacific Aero Products Company, later incorporated as Boeing.

Mark Drela '82, SM '83, PhD '86, the Terry J. Kohler Professor in the Department of Aeronautics and Astronautics (AeroAstro), oversees the new tunnel, built by Maryland company Aerolab. "As we expected, our students and faculty have been blown away by the new capabilities," says Drela. "The tunnel will offer unparalleled opportunities for the MIT community and our industry collaborators to play a part in the future of aeronautics research and education."

1. The tunnel is the largest and most advanced of its kind in US academia.
2. The new tunnel more than doubles the volume of the test section, where models are put through their paces, compared to the original without increasing the facility's footprint on campus—a significant achievement that required an entirely new architecture, Drela says. The ultra-compact facility has 20% of the structural mass of similar-capacity conventional wind tunnels, meaning 80% less steel was needed for MIT's version.
3. The former test section had a 57-square-foot oval flow area and was limited to 150 mph with relatively high turbulence. The new version improves on its predecessor with 90 square feet of space, much better air-flow quality and visibility, and a top speed of 230 mph.
4. To fit a modern, large-capacity wind tunnel into a tiny pocket of Cambridge real estate, designers introduced a number of space-saving innovations such as combining normally separate components and adding a boundary layer ingestion fan with novel-shaped blades that reduce the drive power by 17% and allow a shorter main diffuser, or duct.
5. A MATLAB-based data-acquisition and control system, supported by MathWorks, provides precise control over the tunnel's operations and collects and logs data—replacing an error-prone clipboard-and-spreadsheet method. The system prevents unauthorized access and triggers a shutdown should anything go wrong. In other words, "you can't break the tunnel on a keyboard," says Drela.
6. The tunnel's closest campus neighbors now benefit from a facility much quieter than its clamorous forebear. With the fan running at 120 mph, a noise measurement at a nearby office window revealed levels of 65 decibels, about as loud as car traffic on the street outside.
7. With enhanced power and a host of sophisticated tech, the new tunnel has vastly expanded AeroAstro's research capabilities, Drela says, to include previously tricky high-precision drag measurements; experiments influenced by air flow transitions (work on unmanned aerial vehicles, wind turbine blades, wings, and aircraft bodies, for example); and research that calls on ultraviolet and infrared illumination for motion tracking and advanced flow imaging.
8. Building 17, the wind tunnel's home, has also been overhauled, introducing new space for faculty and the MIT Rocket Team and a new connection to the adjacent Building 33. As a result, AeroAstro now has contiguous space on campus for the first time in its long history. —Tracey Lazos

Donor Spotlight

Hamid Moghadam '77, SM '78 wants to help MIT put its best face forward. His support for the MIT Welcome Center in Kendall Square and for a new Earth and Environment Building at the Green Building, he says, was inspired by his vision of a more inviting campus.

"I thought it would be wonderful to have a focal point where people could have a really great first impression of MIT," the cofounder and chairman of the San Francisco-based Prologis says of the Welcome Center, which is named for him and his wife, **Tina**.

Recently opened as part of MIT's new Kendall Square gateway, the Center has a 200-seat auditorium, art installations, and a fun "Welcome Wall" featuring a photo of the MIT Dome enhanced with illustrations.

It's a space designed with MIT's prospective students and their families in mind. "While MIT certainly has no problem attracting some of the best students—and while substance is the most important thing—presentation is also important,"

"[We hope] to help MIT turn its campus into a competitive advantage."

Moghadam says, noting that he and his wife hope "to help MIT turn its campus into a competitive advantage."

The Earth and Environment Building, currently under construction, offers a similar opportunity, he says, lending a "sense of presence" to the 21-story Green Building, designed by I.M. Pei '40. The new structure will serve as a central hub where students, researchers, faculty, and others can gather for classes, events, and programming on climate, environment, and sustainability issues.

Inside, work will address climate change, "the existential issue of our time," Moghadam says. "The future is all about the kids, the students, and MIT attracts some of the best," he says. "If we are to have a planet in the next 100 years, I think it will be these young minds who are going to do it." —Mark Sullivan

A Campus as Energized as the Community

Continuous renewal and renovation of MIT's physical facilities is an essential component of the Institute's mission to advance knowledge and educate students. During the recent MIT Campaign for a Better World, the MIT community raised more than $600 million in support of capital needs. **JULIE A. LUCAS, THE INSTITUTE'S VICE PRESIDENT FOR RESOURCE DEVELOPMENT**, talks about how this collective generosity is helping to fuel a campus transformation.

To meet the needs of our community, MIT's campus has changed substantially over the past decade and is continuing to evolve. How does philanthropy help make this possible?

MIT is fortunate to have many alumni and friends who share the Institute's vision for a modern, sustainable campus that can equip students, faculty, and staff to take on big challenges—now and decades from now. Our donors have contributed to the creation of new forward-thinking interdisciplinary research, innovation, living, learning, and maker facilities. They have also helped us reinvigorate and maintain MIT treasures such as the Great Dome, Kresge Auditorium, and the Hayden Library and Building 14 Courtyard, plus numerous other spaces that underpin our education and research activities.

Can you share some examples of impactful projects?

It's difficult to pick! The Campaign made it possible to create MIT's first dedicated music building, which is expected to open in 2024. The arts are vital to MIT; hundreds of our students arrive on campus as trained musicians, while others become music lovers through classes or extracurricular activities. The building will have state-of-the-art production facilities, music technology labs, and performance spaces, a huge benefit for MIT and the local community. Next year, MIT will gain a home for the Stephen A. Schwarzman College of Computing at the heart of campus, reflecting the important role computing plays across all disciplines at MIT.

Another notable project is the renovation of the iconic Metropolitan Storage Warehouse building. When it opens in 2025, the Met Warehouse will be a new home for our School of Architecture and Planning and the recently established Morningside Academy for Design. It will also have the largest makerspace on campus.

Where have you seen the most dramatic changes?

It has to be in Kendall Square, which has been reimagined as a thriving new gateway to the Institute. The area now has a new MIT Welcome Center (see story above), Admissions Office, and innovation and entrepreneurship hub. It is also home to the relocated MIT Museum (see story on page 2), a graduate residence, and two acres of open space for everyone to enjoy.

The neighborhood's palpable new energy is a powerful reminder that our campus is so much more than bricks and mortar. Thanks to the generosity of our alumni and friends, MIT has been able to build, restore, and maintain facilities that will empower the world's best thinkers, teachers, and makers for the next century and beyond.

See a list of campus projects during the Campaign for a Better World on page 21.


N
VASSAR STREET
MEMORIAL DRIVE
1
2
3
4
6

MASSACHUSETTS AVENUE
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Evolution of MIT Campus, 2011–2022

*NEW

1. Theater Arts Building
2. New House Residence
3. David H. Koch Childcare Center*
4. Burton Conner Residence *(under construction)*
5. Richard J. Resch Boathouse
6. New Vassar Residence*
7. Music Building* *(under construction)*
8. Kresge Auditorium
9. Metropolitan Storage Warehouse *(in design)*
10. Stratton Student Center *(in design)*
11. MIT Chapel
12. Samuel Tak Lee Building
13. Wright Brothers Wind Tunnel
14. Building 31
15. Great Dome
16. Lisa T. Su Building—MIT.nano*
17. MIT Stephen A. Schwarzman College of Computing* *(under construction)*
18. The Simons Building
19. Hayden Library and Building 14 Courtyard
20. Green Building, Earth and Environment Building* *(under construction)*
21. Ralph Landau Building
22. MIT Museum*
23. Moghadam Welcome Center, MIT Admissions, and MIT InnovationHQ*
24. Kendall Square Open Space*
25. Kendall Square Graduate Residence and Childcare*
26. Morris and Sophie Chang Building

Reinventing Campus

MIT's campus underwent a major reinvention during the Campaign for a Better World. Historic buildings were ushered into the modern age. New residence halls opened, and libraries were revamped. A new facility was dedicated to groundbreaking work in nanotechnology. A portal between academia and industry—and a new gateway to MIT—was established in Kendall Square, while homes for music, design, computing, and Earth and environmental sciences started to take shape.

Completed Since 2011

Building 31
Building 31, home to the departments of aeronautics and astronautics and mechanical engineering, has been transformed into an inspiring, collaborative space for research in autonomous vehicles, turbomachinery, energy storage, and transportation.

David H. Koch Childcare Center (Building W64)
With 11 classrooms, as well as playgrounds, climbing structures, and gardens, this new facility serves children of faculty, staff, and students.

Graduate Residence and Childcare (Building E37)
Rising above the Moghadam Welcome Center and MIT InnovationHQ in Kendall Square, this new residence provides 454 apartments for graduate students and a childcare facility.

Great Dome (Building 10)
Erected in 1916, the Great Dome underwent a full renovation, returning the skylight to brilliance for the first time since it was blacked out during World War II and restoring the Barker Library reading room.

Hayden Library and Courtyard (Building 14)
The renovation of Hayden Library and the Building 14 Courtyard, central elements of the campus for more than 70 years, creates an intellectual town square that fosters connection and collaboration.

Kendall Open Space
Two acres of landscaped green spaces and open spaces invite the MIT and Cambridge communities to gather, connect, and discover.

Kresge Auditorium (Building W16)
A meticulous renovation of Kresge Auditorium, the Eero Saarinen-designed "main stage" of MIT, stabilized the features of this mid-century Modernist landmark while improving visitor comfort.

Lisa T. Su Building—MIT.nano (Building 12)
MIT.nano, inside the Lisa T. Su Building, supports the activities of more than 2,000 faculty and researchers as they work on projects at the nanoscale (one billionth of a meter).

MIT Chapel (Building W15)
The renovation and renewal of the landmark chapel designed by Eero Saarinen brought about needed repairs.

MIT Museum (Building E28)
Occupying 67,000 square feet in Kendall Square, the new museum spotlights collections curated by experts on MIT-based invention.

Moghadam Welcome Center, MIT Admissions, MIT InnovationHQ (Building E38)
This new multiuse building in Kendall Square welcomes prospective students and visitors and provides spaces for student innovators and entrepreneurs to collaborate.

Morris and Sophie Chang Building (Building E52)
The complete renovation of this Art Deco gem along the Charles River, home to the Department of Economics and administrative offices and student services for the MIT Sloan School of Management, revived an aging facility while creating the state-of-the-art Samberg Conference Center.

New House Residence (Building W70)
A thorough renovation brought new life to the 115,000-square-foot residence that is home to 290 undergraduates in nine living groups.

New Vassar Residence (Building W46)
MIT's new undergraduate residence hall built on the site of the old West Garage parking facility provides 450 students with housing close to the heart of campus.

Ralph Landau Building (Building 66)
A modernist icon, this I. M. Pei '40-designed building, home to the Department of Chemical Engineering, has been refreshed.

Richard J. Resch Boathouse (Building W8)
A substantial renovation of this circa-1966 crew boathouse added space for more shells, new fitness areas, upgraded locker rooms, and a larger viewing deck on the Charles River.

Samuel Tak Lee Building (Building 9)
The substantial renovation of this building provides dedicated space for the innovative STL Real Estate Entrepreneurship Lab.

The Simons Building (Building 2)
Home to the Department of Mathematics and portions of the Department of Chemistry, this was the first of the Main Group of 100-year-old Beaux Arts buildings to receive a comprehensive renewal.

Theater Arts Building (Building W97)
The rejuvenation of a former warehouse on Vassar Street creates a home for MIT's theater arts program, which has more than doubled its enrollment in recent years.

Wright Brothers Wind Tunnel (Building 17)
The renovation of the Wright Brothers Wind Tunnel, used since 1938 to test aerodynamics, establishes the most advanced academic wind tunnel in US academia.

Under Construction

Burton Conner Residence (Building W51)
A renewal project slated for completion in fall 2022 will restore this beloved residence's infrastructure and prepare it to serve students well for years to come.

Earth and Environment Building (Building 55), **Green Building** (Building 54)
A new building adjacent to the I. M. Pei '40-designed Green Building will add a major new hub for environmental and climate research. Meanwhile, infrastructure improvements will modernize the iconic Green Building.

MIT Stephen A. Schwarzman College of Computing (Building 45)
The centralized headquarters for the MIT Schwarzman College of Computing will be an interdisciplinary hub for research and innovation in computing, artificial intelligence, and related fields.

Music Building (Building W18)
A new music building sited next to Kresge Auditorium will provide a dedicated home for MIT's conservatory-level music program, which annually enrolls more than 1,500 students.

In Design

Metropolitan Storage Warehouse Building (Building W41)
A renovation of this historic building will provide a new home for the School of Architecture and Planning, the recently established Morningside Academy for Design, and a Project Manus-run makerspace open to the whole community.

Stratton Student Center (Building W20)
A renewal of the Stratton Student Center will improve design, infrastructure, and flexible-use space in this 24/7 central hub of student life.

Tech for Invisible Health Monitoring

Dina Katabi works to bring personalized medicine home

Consider a 75-year-old we'll call Gordon. One day in late February 2020, he had a myocardial infarction—a heart attack—and was rushed to the hospital. Fortunately, Gordon recovered. But he wasn't able to get back to his previous level of mobility.

What if Gordon had had some warning of what was to come?

It turns out that in the six days preceding his heart attack, Gordon's walking was gradually slowing and his breathing rate was increasing. The changes were so imperceptible that no one noticed, not even Gordon. But a small device sitting in his bedroom did. Part of a purely observational study at the time, the machine, the size of a router, was continuously emitting wireless signals (about a thousand times weaker than your WiFi). Those signals, ricocheting off the walls and floors of Gordon's apartment, also bounced off him. The tiniest of Gordon's bodily signals—the pulsing of his veins, the inhale-exhale movements of his chest, the shuffling of his feet—affected these waves, enabling changes to be detected. Think of it as low-power radar.

For this study, the data weren't processed in real time, so no intervention could be made. But machine-learning algorithms were ultimately able to disentangle that complex electromagnetic flurry and reveal Gordon's slowing gait and increased respiration. In other words, this device saw signs of a possible health issue days in advance, at a time when it could have been monitored or treated.

"Once the medical system has more experience with this type of information," Dina Katabi SM '99, PhD '03 says, "it will open up a window into monitoring people's health in their natural living environment."

"Once the medical system has more experience with this type of information," Katabi says, "it will open up a window into monitoring people's health in their natural living environment."

Katabi, the inaugural Thuan and Nicole Pham Professor at the Stephen A. Schwarzman College of Computing, explains that the touchless sensors she and her team are developing represent a move from wearables to "invisibles." Patients consent to having the wireless emitters installed in their homes, but the machines disappear into the background, which means the data depict someone's actual condition. (Brief exams at the doctor's office tend not to accurately reflect patients' day-to-day health experiences.) In addition, there's no need to interface with the device to charge it, enter personal information, or attach it to your body.

These invisibles can register someone's breathing, movements, sleep, and heartbeats through walls and around corners—even from another room. The technology can tell if someone is scratching their eczema, going to the medicine cabinet to take their pills on time, or using their inhaler or insulin autoinjector properly. To see it in action—for example, the moment when someone enters REM sleep and starts to dream registered at a distance without attached sensors—is astonishing. Indeed, when Katabi, who is also a principal investigator in the Computer Science and Artificial Intelligence Lab, did a live demo at one TED talk, the audience broke into applause.

She says two major advances have helped make her work possible. The first is powerful radio technology that can sense faint electromagnetic signals. The second is the revolution in the computer field known as deep learning, which has allowed Katabi and her team to build computer models and signal processing algorithms that can interpret and translate the wireless data into meaningful information about what's taking place in the home.

Tying together math, medicine

Katabi grew up in Damascus, Syria, in a family flush with physicians. Her grandfather was among the first doctors to graduate medical school in the country. Her father is a practicing cardiologist, and many of her cousins are doctors. Katabi did a year of medical school at Damascus University, "but at the time, I just loved math much more." She wound up majoring in engineering, a decision that frustrated her family.

It was a hard choice to make, but now Katabi's current work in wireless signaling has enabled her to embrace math and medicine at once. She's using engineering and computer code to gain a more precise understanding of our physical bodies.

Two thirds of health care costs in the United States are connected to chronic conditions, such as Parkinson's disease, heart disease, cancer, diabetes, and chronic obstructive pulmonary disease. These problems develop gradually. For instance, before someone is brought to the hospital with congestive heart failure, fluid steadily accumulates in the lungs and breathing grows increasingly shallow.

With continuous, remote physiological monitoring, patients can get treated earlier and more precisely, with targeted pharmacological and therapeutic interventions. In other words, says Katabi, wireless monitoring has the potential to revolutionize health care.

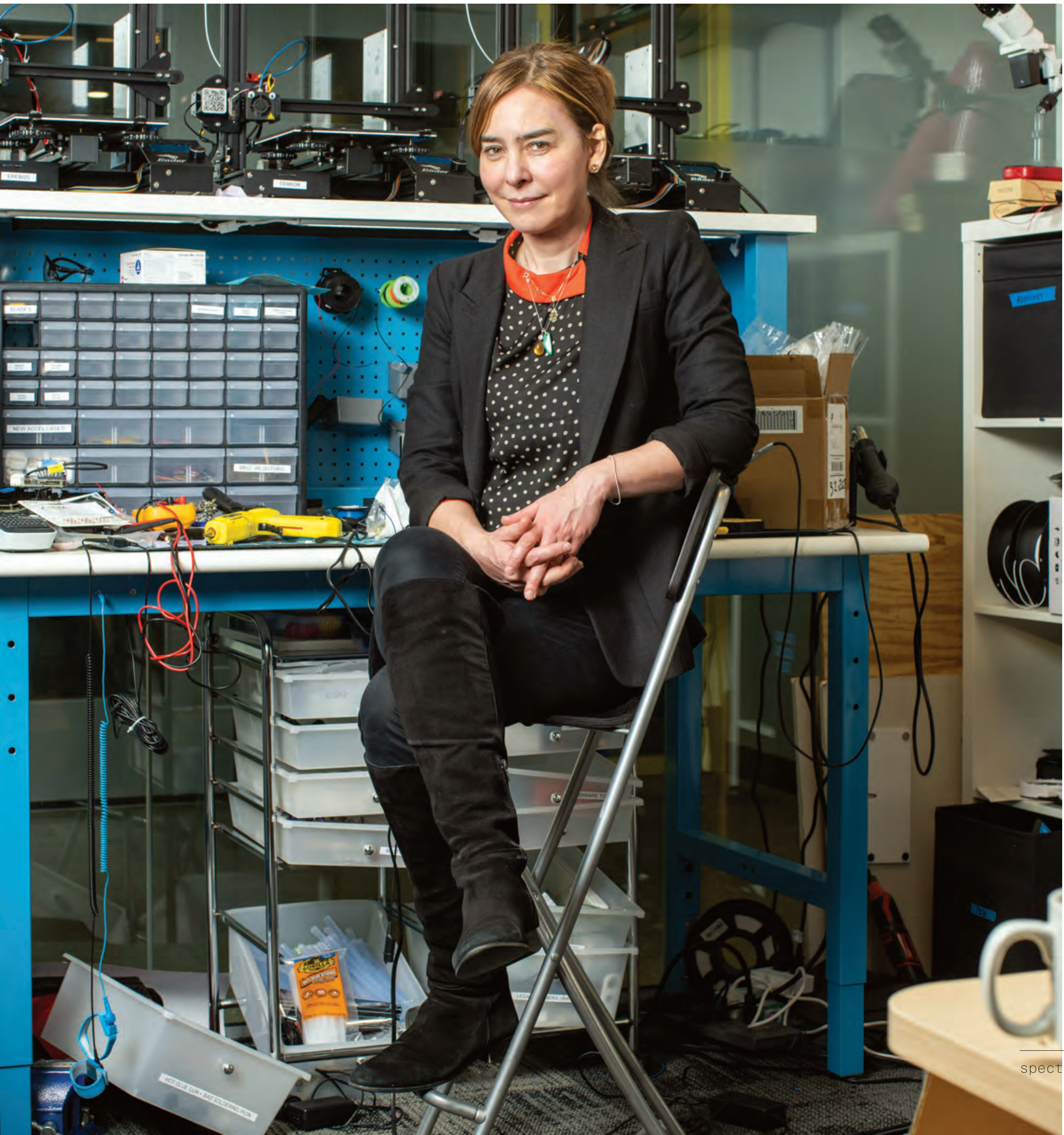
Benefits of home health care

One incarnation of this revolution is "bringing health into the home," according to Katabi. Continuously assessing people's basic vitals and medical conditions where they live has several potential benefits. First, health care costs plummet as the number of in-person appointments, tests, and procedures drops. Second, clinical trials can speed up as it becomes easier to more closely and accurately track subjects as they test experimental treatments and medications. Third, in situations where a disease is highly contagious (think of Covid-19), this technology allows physicians to closely monitor patients with zero contact.

Finally, the quality of specialized care improves. Take Parkinson's, a disease of the central nervous system that causes tremors and difficulties walking and balancing. Some 40% of patients don't have access to specialists by virtue of where they live. Collecting medical information at home and transmitting it to a Parkinson's specialist would dramatically enhance their quality of care. Indeed, Katabi has already collected data that shows how the gait of patients with Parkinson's improves after they take their medication and gradually declines as it wears off. Physicians can use this sort of information to offer individuals precision medicine—personalized, optimized dosing.

Katabi is currently developing tools to enable even more complex monitoring, weaving together breathing, sleep, and behavioral data to diagnose depression or anxiety and forecast flares in Crohn's disease. "Every one of us is very different," she says. Noting that the work promises to improve medicine, Katabi smiles and suggests that she has continued in her family business after all.

—Ari Daniel PhD '08



Dina Katabi and her team are developing touchless sensors for medical monitoring.

PHOTO: M. SCOTT BRAUER

Building Bridges to Better Diagnostics

Collaboration propels work on cancer-detecting patches

In 2019, 20 women diagnosed with ovarian tumors agreed to try out a new MIT-designed skin patch—a small, clear, flexible disc that may one day become the first noninvasive screening tool for ovarian cancer.

Short of a biopsy, there's currently no screening method or diagnostic test for ovarian cancer, the fifth-leading cause of cancer deaths among women. MIT researchers Darrell Irvine PhD '00 and Paula Hammond '84, PhD '93 are melding their expertise in engineering, immunology, and polymer chemistry to change that.

"Ovarian cancer over the past 30 years has seen very little improvement in survivability. We need multiple means of addressing this disease; there's not going to be a single bullet," says Hammond, Institute Professor and head of the Department of Chemical Engineering. The microneedle patch Hammond is developing with Irvine, the Underwood-Prescott Professor in the departments of biological engineering and materials science and engineering, could become a lifesaving tool for the early detection of ovarian cancer.

The work is supported by the Bridge Project, a collaboration drawing on expertise from the Koch Institute for Integrative Cancer Research at MIT and the Dana-Farber/Harvard Cancer Center that brings bioengineering, advanced cancer science, and clinical oncology together to solve today's most challenging problems in cancer research and care.

Finding ovarian cancer

Hammond has a wealth of experience developing biomaterials to enable targeted drug and gene delivery for a variety of challenging disorders. Yet ovarian cancer strikes her as particularly insidious: it's hard to detect and often diagnosed too late to save the patient. Further, unlike cancers with known genetic origins, ovarian cancer has more opaque causes. "We've needed to be much sneakier about how we approach ovarian cancer," Hammond says.

She learned some daunting truths about ovarian cancer in 2013, when she met oncologist Dr. Kevin Elias at the Dana-Farber Cancer Institute. Elias, intrigued by nanomedicine's potential for cancer treatment, became a postdoctoral associate in Hammond's lab at MIT. When he later started his own lab at Brigham and Women's Hospital in Boston and began evaluating microRNAs' (miRNAs) potential as a biomarker, he immediately thought that Hammond and Irvine's microneedle technology could prove useful.

MiRNAs are small, noncoding strands of RNA that regulate gene expression. Made up of nucleic acids that synthesize proteins in all living cells, miRNAs can be found in blood, urine, saliva, and the interstitial fluid between blood vessels and cells.

Elias knew Irvine, whose background is in immunology, and Hammond had been developing microneedle patches as an alternative to traditional vaccine delivery and as a tool for gauging immune responses and pinpointing infections. But Elias had something else in mind.

When Elias asked, "If I can identify a 'fingerprint' of microRNAs associated with ovarian cancer, can we use your tool set to detect it," Irvine says they started thinking about microneedles as a way to sample material out of—rather than delivering things into—the skin.

Sasan Jalili, a postdoctoral research associate at the Koch Institute, helped design the microneedle patches to project only several hundred microns into the skin, where there are few capillaries and pain receptors. The patches are made of a biodegradable, FDA-approved polymer similar to the material used in resorbable sutures. Their tiny prongs are coated with hydrogels, a network of polymers that can absorb water or biological fluids without losing their structure.

This false-colored scanning electron microscope image shows the microneedles used to detect ovarian cancer.

IMAGE: SASAN JALILI

Anasuya Mandal SM ’14, PhD ’17, who completed her PhD under Irvine and Hammond, started making hydrogels out of alginate, a benign seaweed extract. Within the alginate matrix, the team was able to incorporate molecular strands that attract the miRNAs Elias hoped to sample.

The alginate layer swells in the presence of water, absorbing interstitial fluid that may contain miRNAs from cancer cells. “They get captured in the hydrogel, and we essentially isolate miRNA from the patch by dissolving the alginate layer,” Hammond says. These recovered molecules are then analyzed for Elias’s ovarian cancer “fingerprint.”

A mail-in cancer test

The women who agreed to participate in the microneedle patch trial had all experienced pelvic discomfort and had already undergone an ultrasound that revealed an ovarian mass.

Doctors suspected—but couldn’t confirm—that these masses were malignant. Only a biopsy can do that, but in the case of ovarian cancer, biopsies are ill-advised.

“We don’t biopsy the ovaries because it risks seeding the abdominal cavity with cancer cells and worsening the prognosis,” Elias says. “So, the decision is really whether you wait and observe it or remove the whole ovary.”

An accurate ovarian cancer test would make this decision crystal clear. The holy grail, according to Elias, would be a noninvasive, accurate cancer screen that a patient could conduct herself.

“The most practical application for the microneedle patch is a patient who lives in a remote part of Maine, six hours away from specialists,” he said. For such a patient, even coming in for a blood sample might be difficult.

Microneedle patches may one day resemble flexible polymer Band-Aids “that can be mailed to somebody’s house and mailed back,” he says.

The women who generously volunteered for the clinical trial had prototype patches affixed to their abdomens with surgical tape. After 30 minutes, the two-by-two squares were removed and checked for miRNAs. “The results are being analyzed in a blinded fashion, so I cannot tell yet whether the miRNA test correctly identified all of the women with cancer,” Elias says. However, in prior analyses, the test identified about 90% of women with ovarian cancer and had a false positive rate of less than 1%.

> “Ovarian cancer over the past 30 years has seen very little improvement in survivability. We need multiple means of addressing this disease,” Hammond says.

With continued Bridge Project support, the researchers hope to do a more extensive follow-up to see if the patches will detect ovarian cancer in patients who have not yet been diagnosed with an ovarian mass.

Irvine says the Bridge Project “was absolutely crucial because it allowed us—relatively quickly and without a lot of preliminary data—to pitch this novel approach. And we’re now positioned to raise funds from the National Institutes of Health or other sources that might be interested in supporting our work.”

Elias, now director of the Brigham and Women’s Hospital gynecologic oncology laboratory, credits the Bridge Project with enabling higher-risk projects because “the clinicians and the engineers involved can come up with a creative solution to a new problem, rather than focusing on

Donor Spotlight

The head of one of Brazil’s largest retailers hopes his support for postdoctoral fellowships at MIT will help create a digital platform for health that benefits people worldwide.

Fred Trajano is CEO of his family’s Magazine Luiza retail chain; the company’s app, Magalu, has been revolutionizing e-commerce in Brazil. Now, after seeing the devastating impacts of the Covid-19 pandemic, Trajano hopes to support a similar transformation in health care.

“The pandemic awakened in me a particular interest in the transformative role of science and research in society,” Trajano says. “I feel each one of us has an obligation to ensure a better and safer future.”

His gift to MIT has established the Fred Trajano Postdoctoral Fellowship in the Laboratory for Computational Physiology at MIT’s Institute for Medical Engineering and Science. The lab works to improve health care by developing new and refined approaches to interpreting data.

> **“Each one of us has an obligation to ensure a better and safer future.”**

“Big data, artificial intelligence, and predictive analysis are now the lingua franca through which health care professionals communicate as they diagnose, treat, and deliver care. The digital transformation is empowering them to deliver quality care more effectively, more safely, and more efficiently,” he says.

The global marshaling of resources to create vaccines for Covid-19 shows how much can be achieved in science when backed with enough resources, Trajano adds. “This is a trend that will benefit patients everywhere.” —Mark Sullivan

PORTRAITS: KATHY WITTMAN, BALL SQUARE FILMS (IRVINE); GRETCHEN ERTL (HAMMOND)

Donor Spotlight

"Mental health is important for MIT and personal to us."

Henry Lichstein '65, '66, SM '66 and his wife, **Janine**, had a straightforward goal for their MIT philanthropy: expanding mental health services available to students. Having lost their son, Daniel, to suicide during his junior year in college, the couple has supported mental health and suicide prevention programs ever since. Janine has been an active volunteer and board member for a suicide prevention group in their home state of California, while Henry shifted his approach to giving at MIT, seeking effective ways to support MIT students.

After learning about the Institute's MindHandHeart initiative and meeting with leaders of MIT Medical's Student Mental Health and Counseling Services, Henry and Janine created the Lichstein Family Mental Health and Counseling Fund to support a postdoctoral fellowship in clinical psychology and funded it for four years. The inaugural fellow began in the fall 2020 semester, assisting full-time clinicians in caring for MIT students.

"Mental health is important for MIT and personal to us," says Henry. "I would like to think that what we've done will mean better mental health outcomes for people on the MIT campus." Now working with early-stage companies after a 30-year career at Citibank, Henry reflects, "Given that my success was tied to the friends I made and the skills I learned at MIT, it's only right that we support MIT. We were glad to find a creative program in an area important to us. We are delighted by the outcome."
—Christine Thielman

needing to have a large body of preliminary data in order to start sponsoring a project."

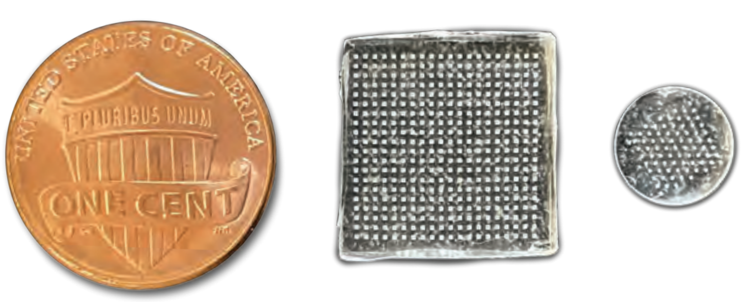
"What's unique about the Bridge Project," he says, "is that it leverages the expertise of the participating institutions."

Meanwhile, MIT researchers are pushing ahead with microneedle technology. Irvine and Jalili are collaborating with the UMass Chan Medical School on using microneedle patches to monitor immune responses to autoimmune diseases such as psoriasis and lupus. Jalili is using the patches to unravel key immune mechanisms regulating the efficacy of potential vaccines against cancer.

Irvine says, "This is an area that's going to continue to grow. We're excited about the potential for using microneedle patches in many different ways, even though it's really a relatively simple device."
—Deborah Halber

MIT researchers are exploring the use of microneedle patches, smaller than a US penny, as a diagnostic tool.

IMAGE: SASAN JALILI



Donor Spotlight

"You have a high concentration of brilliant minds that hunger for really hard problems."

Emily and Malcolm Fairbairn '84, SM '85, of Orinda, California, are on a mission to cure Lyme disease. They want to give hope to people who—like themselves and their family members—have been afflicted.

"I know how people feel and what they're going through," says Emily. "It will take committed, private donors to fund critical research necessary to prevent and treat a disease that affects millions of Americans."

According to the Centers for Disease Control and Prevention, roughly 476,000 people get Lyme disease each year in the United States. Transmitted through the bite of infected ticks, Lyme causes fever, headache, fatigue, joint and body pain, brain fog, and a characteristic skin rash. If left untreated, infection can spread to joints, the heart, and the nervous system.

The couple's support of Lyme research at MIT spans a broad range of efforts, including research led by Linda Griffith, the School of Engineering Professor of Teaching Innovation in the Department of Biological Engineering, and collaborations through the MIT Sandbox Innovation Fund Program to investigate chronic health problems associated with Lyme and Covid-19.

"You have a high concentration of brilliant minds that hunger for really hard problems," Emily says. "We want to help unleash that energy and creativity!"

Emily hopes seeding research projects and facilitating novel partnerships will attract more funding. "Curing this disease will take billions of dollars and a lot of concerted effort by brilliant scientists like Linda," she says. —Mark Sullivan

Applying Analytics to the Opioid Crisis

Research reflects MIT Sloan focus on improving health systems

More than 100,000 Americans died from drug overdoses between May 2020 and April 2021—setting the record for a single year. Most were opioid overdoses, according to the Centers for Disease Control and Prevention. On Staten Island, the statistics are especially grim: historically, the area has suffered the highest rate of unintentional opioid deaths out of New York City's five boroughs and double the rate of the United States overall, with 28.7 unintentional overdoses per 100,000 people each year.

Jónas Oddur Jónasson, an assistant professor of operations management at the MIT Sloan School of Management, and Nikolaos Trichakis PhD '11, the Zenon Zannetos Career Development Professor of Operations Management, are working to address this crisis. They have partnered with the Staten Island Performing Provider System on a proactive program designed to allocate resources to high-need patients based on data. The program is called Hotspotting the Opioid Crisis.

Through this partnership, the MIT team was able to develop a computer model that helps providers predict a range of adverse opioid-related events. Researchers began by accessing data from more than 70 Staten Island care providers, gathering electronic health records and prescription data on 251,781 patients who were either on Medicaid or uninsured. They then applied their artificial intelligence-based analytics system to predict which patients were most at risk of overdosing.

For example, by considering 107 behavioral variables, the system can stratify patients by their risk of opioid overdoses through examining their history of prior prescriptions and interactions with the Staten Island health care system. It can also capture the number of short-acting hydrocodone prescriptions filled in the past 90 days or the number of benzodiazepine refills. In this way, the team's algorithm can identify the top 1% of the highest-risk patients, who in turn account for 69% of adverse opioid events, Jónasson says.

Their model can help health care teams conduct targeted interventions, steering limited resources to the most vulnerable. It's a potent example of the type of impactful work funded by the MIT Sloan Health Systems Initiative (HSI), according to HSI Director Anne Quaadgras '85, SM '86.

A program within the MIT Sloan School of Management, HSI funds and amplifies research, convenes experts, and advances networking opportunities to tackle urgent issues in health care. Research centers on analytics, operations, and incentives that promote healthier behaviors to reduce costs.

"Our goal is to bring researchers and practitioners together to innovate and implement systemic health care solutions," Quaadgras says. "There are lots of places that do health research, but they're usually in medical schools and public health schools. There are far fewer that are really focused on health systems and delivery systems."

HSI has invested in projects ranging from developing analytics to support liquid biopsy for cancer detection to analyzing the health care costs of postmortem genetic testing. Approximately 30 Sloan researchers with roughly 80 working papers are affiliated with HSI.

In another HSI-supported effort, Jónasson has been conducting behavioral analytics research on tuberculosis (TB) patients in Kenya. He and his team are assessing the benefits of a treatment-adherence support platform called Keheala, which offers automated medication reminders, motivational messages, and personal outreach from peer sponsors (people who have overcome TB themselves).

The lack of adherence to treatment protocols is a major barrier to global efforts to eradicate TB, Jónasson says, so it's important to find interventions that work. In the Keheala study, researchers found that outreach to patients from peer sponsors increased the odds of verified next-day treatment adherence by 35%. This work helps to validate the costly but impactful program, Jónasson says.

"This type of work illustrates how data science and analytics can have a material positive impact to societal welfare and can help improve the world we live in," Trichakis adds.

Jónasson says that such work on behavioral issues is the next step for the burgeoning field of precision medicine, which uses artificial intelligence and machine learning to improve medical decision making and to personalize medicines. "It's interesting to try to increase precision—doing the right thing for the right person at the right time," he says. "The idea is to bring precision to behavioral health and social services, which contribute to health."

—Kara Baskin

ILLUSTRATION: ISTOCK.COM / AH_DESIGNS

Scientific Lens Focused on Policy

Economists offer insights and interventions for health care, education, work

What motivates an MIT economist?

"I entered the field to figure out how to make some progress on big, fundamental problems in society," says Parag Pathak, the Class of 1922 Professor of Economics in the School of Humanities, Arts, and Social Sciences, and a director of Blueprint Labs, a policy-oriented economic research group at MIT. "One of these problems is the inequality of opportunity."

David H. Autor, the Ford Professor of Economics, specializes in the impacts of technology on work. He wants to understand "how we minimize adverse consequences of a changing economy and shape opportunities to create a world we all want to live in."

Driven by such concerns, Pathak and Autor, as well as such departmental colleagues as Joshua Angrist, recipient of the 2021 Nobel Prize in Economic Sciences, and 2018 MacArthur Fellow Amy Finkelstein PhD '01, are engaged in research with the power to reshape key sectors of public life—work supported by the MIT Campaign for a Better World. Their studies of health care, education, and the workforce—grounded in theory, novel experimentation, and data analysis—provide insights that frequently capture the attention of the press and sometimes shake up their field.

"We have been a pioneering department for decades, and successful because we are highly innovative while at the same time quite practical," says Autor. "New ideas start at MIT and diffuse from there."

Randomized trials light the way

In 2008, Finkelstein, the John and Jennie S. MacDonald Professor of Economics, encountered what she calls a "once-in-a-lifetime opportunity": the state of Oregon was running a lottery to allocate a limited number of health care slots to uninsured citizens. She sprang into action to take advantage of this real-world, randomized trial. With research partner Katherine Baicker (now at the University of Chicago), Finkelstein evaluated the effects of Medicaid coverage on the uninsured, following both the lottery winners and losers over several years.

The study's notable findings—that health insurance coverage diminished financial hardship, for example—landed on front pages and fed public debate about Medicaid expansion.

"What we did was not rocket science; it was economic science," says Finkelstein. "The incredible response to Oregon showed a real demand and appreciation for evidence."

Finkelstein realized that vanishingly few interventions tailored to improve the delivery of health care were subject to the kind of strict evaluations typical of medical research, and she decided that needed to change. She launched the US Health Care Delivery Initiative (HCDI), a research program based in MIT's Abdul Latif Jameel Poverty Action Lab (J-PAL).

With a dual mission of research and policy action, the initiative identifies significant health care issues, and in partnership with affiliate researchers, health care organizations, and government agencies, conducts randomized controlled trials that generate evidence about the efficacy of a health care intervention.

PORTRAITS: LILLIE PAQUETTE (ANGRIST), JOSH FRANZOS (AUTOR), BRYCE VICKMARK (FINKELSTEIN), M. SCOTT BRAUER (PATHAK)

In the past few years alone, HCDI researchers have investigated a wide range of health-related questions, such as the relative benefits of different treatments for renal disease, the possible effects of provider race on the health behavior of Black men, and the effectiveness of employee wellness programs.

In one case, HCDI research helped develop letters health care agencies could use to persuade physicians to stop overprescribing powerful opiates. Finkelstein worked with a former student who successfully designed and tested an effective version of this intervention, leading to a major reduction in prescription rates. “I see myself as a research activist, increasing appreciation for rigorous evidence, training the next generation to get evidence, and then getting that evidence out in the policy world,” she says.

Scanning future projects, Finkelstein says she is “incredibly excited about people in our network seeing what happens if we forgive people’s medical debt, which can be psychologically and financially crushing.”

“We have been a pioneering department for decades, and successful because we are highly innovative,” Autor says. “New ideas start at MIT and diffuse from there.”

Cause and effect in education

At Blueprint Labs, founded as the School Effectiveness and Inequality Initiative in 2012, Pathak and Angrist, the Ford Professor of Economics, wield research from the fields of market design and econometrics to illuminate issues in education that are of broad concern to the public and decision makers alike.

“The most important, systematic determinant of family income is the human capital of earners, the schooling of earners,” says Angrist. “If you get a college education, the odds of being in poverty go way down.” The corollary is that the quality of schools matters, Angrist adds, and if schools don’t impart essential skills to graduates “then schooling doesn’t have an inequality-ameliorating effect.” Angrist’s pathbreaking empirical strategies measure the effects of policies intended to influence the quality and accessibility of schools, research that can be used to improve policy.

With evidence from such research in hand, Pathak has in the past decade provided public school systems in Boston, New York, Chicago, and elsewhere with a more efficient and equitable method for allocating seat assignments in highly desirable schools. With an algorithm similar to that used by Uber to link riders with drivers, Pathak’s approach impartially matches students to their choice schools.

“Something that makes us distinct is that we love to interact with practitioners,” says Pathak of MIT economists. “Much of our research is animated by someone with real concrete problems, who calls us up and says, ‘What should we do?’”

Complementing this work, Angrist is refining the measurement of school quality. One of his studies challenges long-held claims of exceptional academic effectiveness by exclusive exam schools like the storied Boston Latin School and New York’s Bronx Science. Angrist, Pathak, and their collaborators demonstrate that attendance at these selective schools has “no actual causal effect on learning,” he says.

Breaking down what he calls this “elite illusion” serves as a great teaching moment in Angrist’s undergraduate econometrics class, he says. Students are surprised to learn that many of them likely did well academically not because of their school but because they were smart anyway, Angrist says.

ILLUSTRATION: SEHYR AHMAD

Angrist, Pathak, and their Blueprint Labs partners have shown that public preschools boost college attendance, and they have revealed that urban charter schools can elevate student achievement. Now they are producing findings relevant to the ongoing debate about making education at all levels more affordable and accessible.

Blueprint Lab's primary goal, says Pathak, is "understanding the role of schools in the production of opportunity."

Taking agency in the workplace

In spring 2018, MIT President L. Rafael Reif handed Autor his marching orders: organize a task force to address the ways that technology is changing the nature of work. Two-and-a-half years later, the interdisciplinary Work of the Future group wrapped up its challenging assignment with dozens of expert papers and a major report, Building Better Jobs in an Era of Intelligent Machines.

But the task force didn't just focus on the impacts of artificial intelligence, autonomous vehicles, manufacturing, and supply chains, Autor says. "We also wanted to understand the levers that shape how we adapt to technology and how we shape technology itself."

The idea of agency plays a major role in Autor's research. "Technological changes and economic phenomena are driven by incentives and priorities and people's vision of what the future is supposed to be," he says. "This is something that MIT, and government, and we collectively as society, shape."

Consonant with this view, Autor launched a Work of the Future initiative based at J-PAL, which focuses on exploring ways to help people who lack significant formal education to find high-quality jobs. "This is the biggest problem of the US labor market right now, with 35% of adults stuck in low-paid jobs," he says. Technology has had a huge effect in hollowing out middle-tier jobs, and "the question is how to get people onto career ladders that lead elsewhere."

Campaign funds are supporting the drive for answers, enabling Autor and a far-flung network of research partners to evaluate evidence from programs that explicitly address this problem. Among these is a program in New York that trains non-college-educated adults for 15 months, then places them in technology jobs where they earn on average four times their previous income.

Autor also devises his own real-world experiments. One project aims to determine whether establishing a minimum, livable wage for restaurant workers can also reduce employee turnover at their companies. Another involves studying whether relaxing criteria on criminal background checks can offer a path out of hardship to workers while sustaining employer satisfaction.

"Many employers won't touch people with nonviolent misdemeanors, a category in the criminal justice system where minorities are hugely overrepresented," Autor says. "This is a matter of equity in opportunity."

He is eyeing another experiment with potentially enormous payoffs for employment equity: eliminating the college requirement for jobs in such areas as tech support, programming, and computer security. "A vast majority of people who are Black and Hispanic don't have four-year degrees, and yet that has become the *sine qua non* for all kinds of positions—not always the correct decision," he says. Autor is joining with partners from the corporate world to advance this research.

For Autor, this research is not just about "describing how the world is working but improving how things work." He might well be speaking on behalf of his fellow economists. "Applying a scientific lens to the world's most pressing problems—that's where our energy is dedicated." —Leda Zimmerman

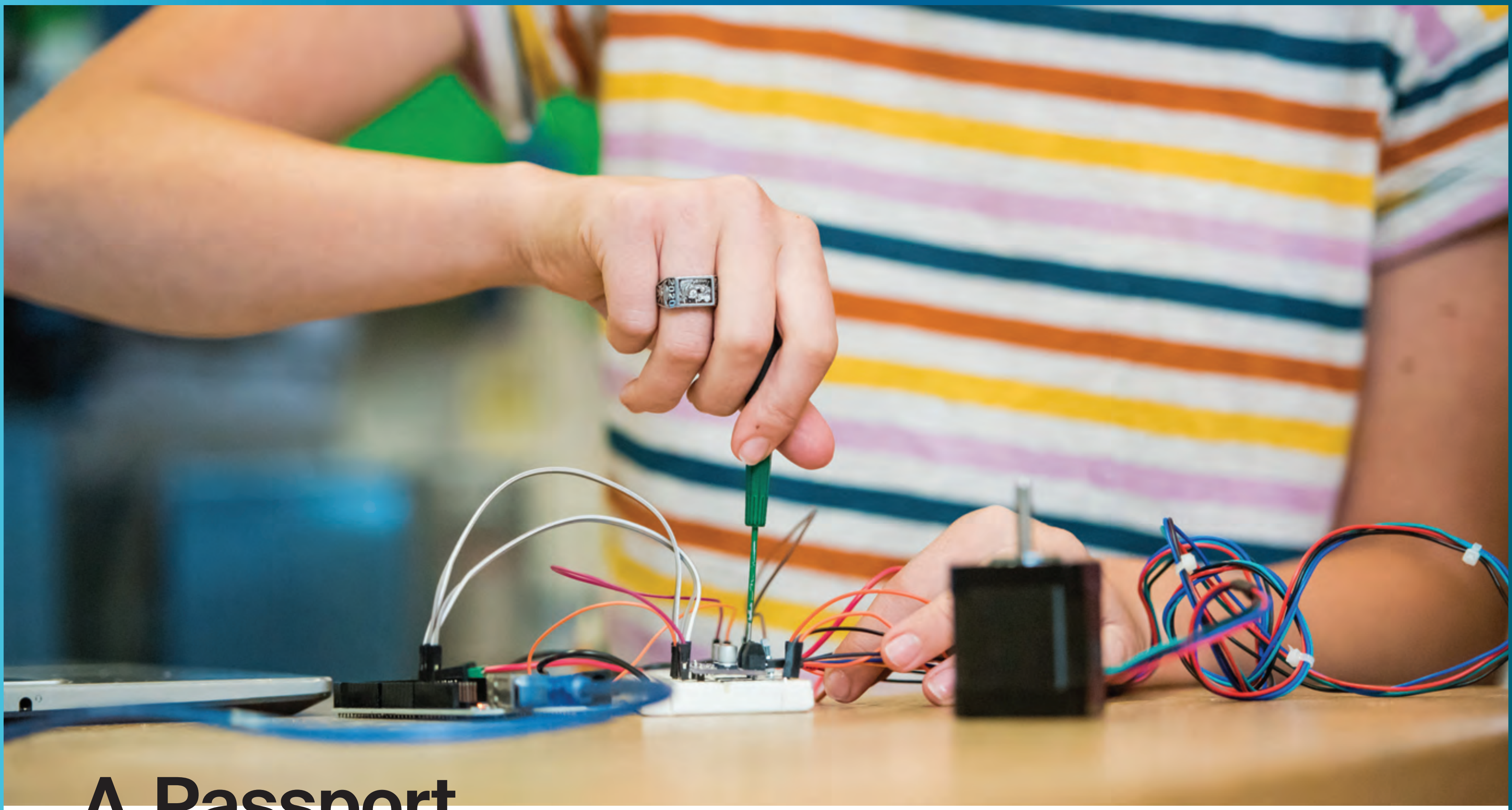
Donor Spotlight

As a native of Hong Kong and a devoted MIT alum, **David Wu '90** is delighted to be part of the MIT Hong Kong Innovation Node—MIT's first regional center dedicated to fostering innovation. Wu, who is president of the MIT Club of Hong Kong, says the Node extends generations-long connections between MIT, Hong Kong, and the Greater China Region. "I find it very rewarding to support a new base for MIT here in my hometown."

Since its launch in 2016, the Node has hosted a range of events and programs (some in conjunction with the MIT Club of Hong Kong), including student hackathons and a startup boot camp called the MIT Entrepreneurship and Maker Skills Integrator. The Node also supports Smart City, a sustainability project that engages the MIT Media Lab with Hong Kong's urban planning; Wu calls this initiative a perfect example of the Node's potential to "build solutions for real-world problems facing our region and the world. This is innovation at its best."

"Innovation Node brings out the best of MIT here in Hong Kong."

"The driving question of the MIT Better World Campaign was, 'How can we leverage the best of MIT to make the world a better place?' The MIT Hong Kong Innovation Node really does that, and brings out the best of MIT here in Hong Kong," says Wu. "For me, there's no better way to express my enthusiasm for this initiative than through a financial gift." —Kris Willcox



A Passport for Makerspaces

Web portal helps MIT community put creativity into practice

An enhanced web passport to the dozens of makerspaces on campus is enabling students and alumni to immerse themselves more quickly in making things, an activity that is central to the MIT experience.

The Mobius web portal, which began in 2016 as an app mapping campus makerspaces and machines, is now piloting the added capability of displaying users' experience and proficiency on various pieces of machinery. A student trained on a laser cutter in one makerspace, for example, can call up a "Mobius Credential" and bypass hours of retraining to use a similar machine in a different makerspace, a real time-saver.

"Mobius basically gives you x-ray vision for the entire campus: you can see any machine, anywhere," says Martin Culpepper SM '97, PhD '00, a professor of mechanical engineering and the director of Project Manus, the Institute-wide effort to upgrade campus makerspaces and foster student maker communities. "The site is the student's passport, their gateway to get in and move between the different makerspaces."

The credentials program is one of the many ways Project Manus—supported by making enthusiasts from inside and outside the MIT community—is fostering the art and practice of making across campus. "One-hundred-forty years ago, the original document incorporating MIT called for applying science and technology to solving real-world problems," Culpepper says. "That doesn't happen if you just read from a book. Making things is what MIT is all about."

Some 40 makerspaces and student-accessible shops are in operation across the Institute. In addition, plans are underway to create the largest makerspace on campus, slated for a 2025 opening on the ground floor of the renovated Metropolitan Storage Warehouse. The Project Manus-run space will be available to all students, alumni, faculty, and staff.

The new process on Mobius enables students or alumni visiting a makerspace to instantly call up their proof of training and safety checkoffs on a given machine.

"Using the website, students sign in through the iPad, and their names and credentials show up on a big monitor right in the shop," says Silvia Knappe '21, a graduate student in electrical engineering and computer science who teaches students to use bandsaws, drill presses, and sanders in the Metropolis makerspace. "I find that really useful as a mentor, especially during open hours: if someone comes in, I can see if they need help potentially with the tool they want to use, or if I can just leave them be because they are very experienced at what they are doing."

Noting that Mobius already has more than 2,000 users, Culpepper says the goal is to make using makerspaces as regular a part of the student routine as heading to the library and the gym. "Every student at MIT should be a maker. They should never feel they can't make something whenever they want to make it," he says.

Robyn Goodner, maker technical specialist for Project Manus, says working on even "super low-fidelity" projects in the shop can spark ideas for solving problems, such as the time a graduate student mentor got an idea for his bioengineering fluidics project while making foil decorations for a holiday party. "A lot of knowledge comes from actually making things and fabricating," Goodner says.

Students agree.

"I like helping other people with their projects because it gives me ideas for my own," said Cat Arase '22, a senior in mechanical engineering who is active in the blacksmithing lab and leads training sessions in the Metropolis makerspace for those interested in waterjet cutting.

"There's a lot of creative inspiration just being there," Knappe says of the Metropolis makerspace. "I love to de-stress by making things."

MIT's makerspaces have been employed on projects as diverse as constructing a novel rocket motor system, fabricating race car parts, exploring ways to count white blood cells, and working with novel chemical compounds and biological systems, Culpepper says. "These kids just apply their MIT ingenuity to problems, and it works amazingly." —Mark Sullivan

PHOTO: SARAH BASTILLE PHOTOGRAPHY

Startup Grows from Sandbox

MIT seed fund helps Ivu Biologics improve agriculture

As global food demand rises, agriculture is under threat. Climate change is damaging soil through erosion and salinization, forcing farmers struggling with crop yields to rely on synthetic nitrogen fertilizers to boost production. It's a vicious cycle: these soil additives require an energy-intensive manufacturing process that releases carbon, which contributes to greenhouse gas emissions.

Augustine Zvinavashe '16, PhD '21 is hoping to change this through his startup, Ivu Biologics. The company is named for a term for soil in Zimbabwe, where Zvinavashe grew up and first became interested in agriculture. With key support from the MIT Sandbox Innovation Fund Program, Ivu seeks to disrupt approaches to farming with a microbe-delivery platform that aims to reduce pollution, build seed resilience, and increase crop yields.

"We're trying to solve a societal problem. We know that by 2050, we're going to have a 30% increase in our population. We need to increase food production by about 70%. We know we need to find more sustainable agriculture," says Zvinavashe, who launched Ivu in 2020. He collaborated with Owen Porth, an MIT PhD student in biological engineering, and Mira Kingsbury-Lee, an undergraduate at Harvard University. Zvinavashe earned his PhD in civil and environmental engineering under Associate Professor Benedetto Marelli and is now a postdoctoral fellow at the MIT Climate and Sustainability Consortium.

Coating seeds with microbes

Today many farmers use fertilizers comprised of synthesized chemicals such as nitrogen, phosphorus, potassium, sulfur, and sometimes micronutrients. "While effective, they can cause harm to the soil and surrounding environments over the long term," Zvinavashe says.

As an alternative to synthetic additives, Ivu has found a way to enrich the soil using living microorganisms, or microbes. In the lab, Ivu creates seed coatings that hold these

fragile microbes and release them into soil when planted. This process promotes the uptake of essential plant nutrients such as nitrogen, phosphorus, and potassium—even in inhospitable soils. The problem has been ensuring the microbes stay alive, and Ivu's technology solves this challenge, Zvinavashe says.

Importantly, the coating is biodegradable and climate-resistant. Farmers will reap the benefits such as higher crop yields, reduced fertilizer costs, and better soil quality. Zvinavashe notes that 33% of soil is currently degraded worldwide; 90% could be degraded by 2050 due to climate change, according to UN data. "We need to change how we're farming. We need to reduce carbon emission and adopt climate-resilient technology. As weather becomes more volatile, soil nutrients will become more depleted," he explains.

The startup is an outgrowth of his doctoral thesis on engineering seed microenvironments, a project Zvinavashe traces back to his childhood, when he worked on his grandmother's farm.

"We grew up in nature, learned how to coexist with animals domesticated or wild, and hiked for fun. Farming incorporates a lot of skills: you learn hard work, people management, how to count, and money management. The idea of running my own company was seeded at an early age," he says.

"We're trying to solve a societal problem," Zvinavashe says. "We need to increase food production."

Donor Spotlight

MITdesignX "is a very healthy way to create innovation."

Blending disciplines is part of daily life for **Liam Thornton SM '92**, executive vice president of development for Live Nation Entertainment and a graduate of MIT's School of Architecture and Planning (SA+P). Thornton says his work developing music venues places him "at the intersection of real estate development and live entertainment."

"I've been fortunate to use my MIT experience as a platform in my career," says Thornton, who studied at SA+P's Center for Real Estate. Today, he fosters interdisciplinary education by supporting MITdesignX, an academic program at SA+P dedicated to design innovation and entrepreneurship. "MITdesignX is all about innovation in the built environment," he says, noting that the program draws from many parts of the Institute, including SA+P, the MIT Sloan School of Management, and the School of Engineering. "This is a very healthy way to create innovation."

Through his contributions, Thornton bolsters MIT values that align with his own, including using "design-driven methodologies to address the multiple dimensions of a challenge, from political and economic aspects to technology and design issues." He hopes his support will inspire MITdesignX students from a variety of disciplines to seek solutions to real-world problems in a spirit of innovation and creativity "while giving them the practical tools to make their ideas a reality." —Kris Willcox

Crucial seed funding

In the effort to save Earth's soil, Ivu is in a race against time, but MIT Sandbox has played a crucial role in accelerating its development with seed money (no pun intended) and lab space. Sandbox provides up to $25,000 as well as mentorship that enables student innovators to explore ideas, take risks, and prepare for the launch of their businesses. It accepts teams at any stage of the startup process that demonstrate strong commitment and a willingness to invest in initial research and planning.

"At MIT, you have a lot of people interested in making the world a better place. Sandbox gives you capital to explore your idea, and you have mentors and entrepreneurs who have done it before. If you have the energy to chase your idea and what you believe in, you can do it here," Zvinavashe says.

Augustine Zvinavashe '16, PhD '21 received support from the MIT Sandbox Innovation Fund Program to launch his startup, Ivu Biologics.

PHOTO: SARAH BASTILLE PHOTOGRAPHY

In particular, he adds, MIT allowed Zvinavashe to use its Huang-Hobbs BioMaker Space, which provided a key advantage. "Lab facilities are so expensive in Boston. Having had an opportunity to use the maker facilities was amazing, because it lowered our development costs pretty significantly," he says.

The future looks bright: Zvinavashe completed his doctoral work this fall, and Ivu is currently in the process of a material transfer agreement with a Fortune 500 company in the hopes of reaching areas with particularly compromised soil, starting in the United States.

"This is exactly what MIT Sandbox was designed for: providing seed funding and mentorship to student innovators looking to find great applications to their research and using entrepreneurship to explore ways to get those innovations to the market. Augustine has fully embraced the educational goals of Sandbox," says Jinane Abounadi SM '90, PhD '98, executive director of the MIT Sandbox Innovation Fund Program.

Zvinavashe is confident that this idea, grown at MIT, will someday take root worldwide as farmers and distributors realize the long-term economic and environmental benefits of biologics.

"I believe this is how we're going to be doing agriculture. Biologics will be super-important. And as it becomes more challenging to farm because of climate change effects, we're going to need technologies that are climate resilient," he says. "Everyone needs to eat." —Kara Baskin

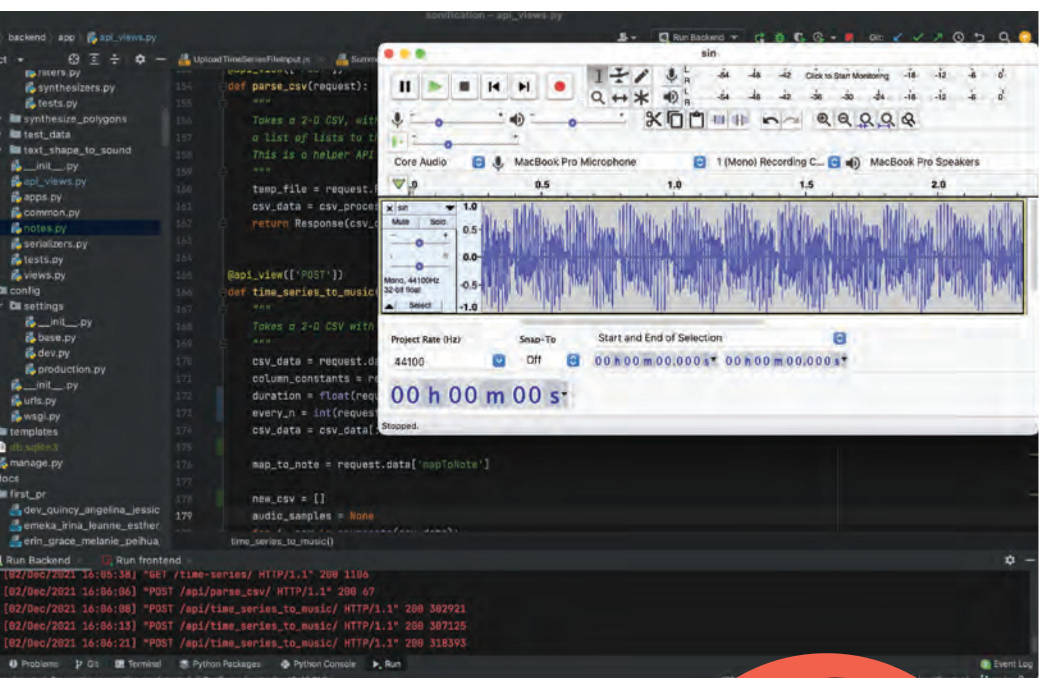
‘Mens et Manus’ in Action

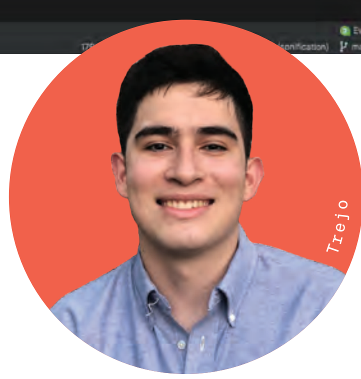
Wildly popular, UROP is—as one student says—“learning how you want to learn”

What do synthetic biology, machine learning, experimental music, and nuclear engineering have in common? They are among the seemingly endless areas of research explored by participants in MIT’s Undergraduate Research Opportunities Program (UROP).

One of the first programs of its kind in the United States, UROP was founded in 1969 by Margaret MacVicar ’65, ScD ’67 to give undergraduates firsthand experience grappling with problems that have never been solved—the essence of research. Today, the program supports nearly 6,000 projects yearly with 93% of MIT graduating seniors participating in at least one UROP during their undergraduate years.

“From the first day they arrive on campus, MIT undergraduates are ready to make a meaningful difference. UROP channels that energy and combines it with the expertise and insight of MIT’s research community,” says Ian A. Waitz, vice chancellor for undergraduate and graduate education.





For his UROP, Moises Trejo ’22 worked on turning data sets into sound waves such as those shown in purple in this screenshot.

IMAGE: COURTESY OF MOISES TREJO

“Undergraduates bring a terrific ingenuity, perspective, and passion to MIT. It is easy to understand why so many of our faculty believe these students are so integral to their research,” says Michael Bergren, associate dean and director of UROP. Noting that UROP received robust support throughout the Campaign for a Better World, Bergren adds that the UROP Office gets more than 60% of its funds for student support from philanthropic sources.

UROPs are available in every MIT department, and the projects students work on vary widely, from measuring the competitiveness of markets in the pharmaceutical industry to harnessing wave energy in order to rebuild beaches. But whatever the specifics of the research, in every case undergraduates collaborate with MIT’s world-renowned faculty and learn to tackle real-world problems. For many, the experience is life changing.

“UROP has been the highlight of my time at MIT,” says Zoë Marschner ’23, a double major in math and computer science who did her UROP project on geometry processing. “I got to deepen my knowledge of math and computer graphics and coding, while also learning how to write a paper and create figures. I really value the variety of skills I learned.”

New perspective

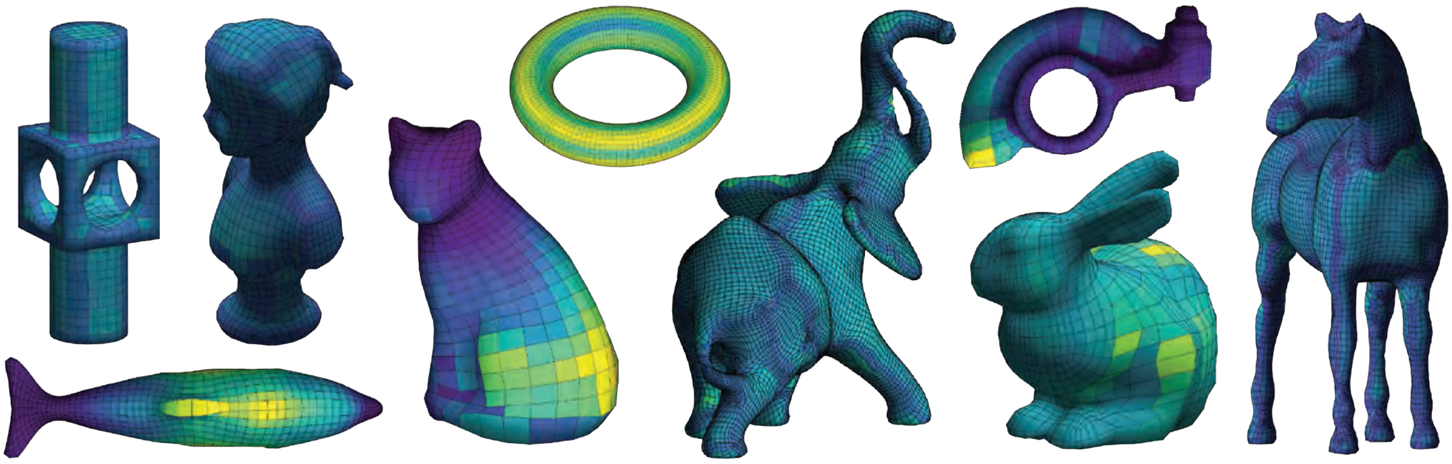
UROP is all about “learning how you want to learn,” says Moises Trejo ’22. “The most important thing about MIT is the people, and classes give only a narrow view. A UROP gives you much more opportunity to do your own research and to talk to faculty and others about cool research.”

An electrical engineering and computer science (EECS) major, Trejo spent this past fall working with Evan Ziporyn, the Kenan Sahin Distinguished Professor of Music, on digital sonification, a project focused on turning data sets into sound. Trejo describes the project as “a toolkit for anyone who wants to make music” and notes that this UROP experience has given him a new passion: “I’m really big into music now.”

Ziporyn, a noted composer, conductor, and clarinetist, says sonification has rich potential as a composition tool but many musicians lack the technical skills to deploy it. So, with a fellowship in the Digital Humanities (DH) Lab in MIT’s School of Humanities, Arts, and Social Sciences (SHASS)—host to a broad range of UROP projects—Ziporyn worked with DH Associate Director Ryaan Ahmed to organize roughly two dozen UROP students to explore different aspects of sonification, developing an open-source tool that anyone will be able to use.

Some UROP students are working on the sonification of colors, turning hexadecimal color codes into sound. Others are making sound from polygons, turning plotted points into music. Trejo focused on converting timed series into sound. For example, he collected the times of sunrise and

PORTRAITS: KEZIA LOPEZ (TREJO), ROKAS VEITAS (MARSCHNER)



Zoë Marschner '23 did her UROP project on geometry processing, which is useful in creating computer simulations of physical objects such as those above.

IMAGES: COURTESY OF ZOË MARSCHNER

sunset over the course of a year to create a composition of those diurnal cycles. "I don't think I'm that skilled at making music, but I made this," Trejo says.

"Moises has taken a lot of personal initiative, consistently coming up with fascinating and surprising sonifications," Ziporyn says.

Trejo says that sharing his new music-making experience with others has given him a rich new way to connect with friends and colleagues. "Just talking to people about what I've done, I've learned so much about other people," he says.

In addition, Trejo says UROP is an ideal way to connect with faculty members because these projects are often the ones faculty care most about. "MIT has world-class faculty in every area, and they're willing to take you on and teach you everything," he says. In particular, Trejo recommends SHASS research. "There are world-class choreographers, historians, musicians, everything in the humanities—and people sometimes don't take the time to explore that area."

Career training

Marschner touts her UROP experience because it has given her the chance to try out her chosen career path. "Doing research all day is definitely something I love," says Marschner, who hopes to become a professor of geometry processing.

She has been working with Justin Solomon, an associate professor in EECS, on a on a novel application of a mathematical technique called sum-of-squares optimization. The work holds promise for improving computer simulations of physical objects, such as those used in computer-aided design, architecture, gaming, and animated movies.

"My work is some of the first to apply this technique in my field, and I've shown how it can be used to formulate algorithms on representations of 3-D shapes more mathematically complex than representations traditionally used," Marschner says. "Eventually, this work may make it possible for these representations to be used to improve a large array of applications, like clothing in Pixar films or simulations of structural properties of mechanical parts!"

UROP, Marschner says, has given her the freedom to follow her own research path. "I got to create my own problems to solve to help me learn the material," she says. "I really enjoyed the self-directed aspect."

Already, Marschner's research has led to two published papers in geometry processing, a subfield of computer graphics. Further, she has gotten the chance to present her work (virtually, due to Covid-19) to the research community, including at the Toronto Geometry Colloquium and at the SIGGRAPH Asia 2021 Conference, a major computer graphics conference.

"Getting to present at real conferences has been great," says Marschner, who got a job conducting research at the University of Toronto last summer thanks to a contact she made at the Toronto event. "I've gotten so much experience on paper writing and presentations, which is really hard to learn in a classroom." —Kathryn M. O'Neill

UROP by the Numbers [2020–2021]

93%

of the MIT Class of 2021 took part in UROP before graduating

60%

of MIT faculty served as UROP mentors

2700+

MIT undergraduates participated in UROP

High-Tech Glasses Grab Attention

MIT Integrated Learning Initiative supports research to help the mind focus

Imagine putting on a pair of glasses and the outside world melts away. Chat notifications turn off. Pings from the never-ending news cycle are silenced. Your mind is gently nudged to focus on the one task that demands your full attention.

This is what happens when you slip on AttentivU, a pair of smart glasses designed by Nataliya Kos'myna and Pattie Maes, both of the Fluid Interfaces group within the MIT Media Lab. Supported by a grant from the MIT Integrated Learning Initiative (MITili), the AttentivU project is designed to help students improve their ability to focus on a given task, such as homework.

"These glasses pick up brain wave activity and eye movements that can be used to recognize whether a person is engaged or not," says Maes, professor of media technology in MIT's Program in Media Arts and Sciences and head of the Fluid Interfaces group.

The glasses are kitted out with sensors: electroencephalogram (EEG) around the ear to detect brain waves and electrooculography (EOG) on the nose bridge to track eye movement and the rate of blinking. EEG works by detecting the electrical signals in our brains. EOG sensors detect the difference in voltage between the cornea and retina, which changes as the eye moves. The system, which is camera-free and microphone-free to ensure privacy, is calibrated before each use with a series of preprogrammed tasks to account for any individual and day-to-day variations.

"We then start the users on their assignment and look at brain oscillations," says Kos'myna, an MIT research scientist and project lead on AttentivU. "We interpret the different combinations of oscillations and combine that with data from the EOG to get detailed information about attention."

These data are fed into an app and processed using machine-learning algorithms, which provides users with real-time information on their state of attention. The system can then provide auditory or haptic feedback to nudge the user back on track when attention wanes or silence social media apps to allow the person to keep going when they are very engaged.

The science of learning

MITili, a division of MIT Open Learning that supports research on the science of learning and learning effectiveness, has funded the AttentivU collaboration since 2020. The system has been in development since 2016, with more than 10 peer-reviewed publications to date. Studies have examined the system's effectiveness in homework-type situations, classroom-based projects, and in addressing drowsiness while driving.

The glasses are noninvasive and portable, especially when compared to the probes and helmets typical of brain-sensing research, opening neuroscientific research up to new questions that can be studied in situ. The system is already being used to study and help populations with limited speech ability. For example, it is being used by people with advanced amyotrophic lateral sclerosis to communicate their needs to caregivers.

Maes and Kos'myna hope that AttentivU will eventually be commercially available as a short-duration-use tool for boosting focus. "No one should wear the glasses each day, all day. It's not healthy or even possible to be focused for that long," says Kos'myna. "Rather, you'd only use them for a while when you need to be focused."

MITili has been able to sponsor projects like AttentivU thanks in part to support raised through the MIT Campaign for a Better World.

"We really resonate with the theme of that campaign," says Maes. "Most of what the Media Lab does is develop new technologies that help provide more self-sufficiency to people and communities. It really motivates the students and the faculty to work on something they know will make a difference in someone's life."

—Stephanie M. McPherson

"These glasses pick up brain wave activity and eye movements that can be used to recognize whether a person is engaged or not," Maes says.

AttentivU smart glasses are designed to help students focus. They are modeled here by Chi-Yun Hu, a student who worked on the project.

PHOTO: CASSANDRA SCHEIRER

Donor Spotlight

While serving on the Student Life Visiting Committee, **Ricardo Jenez '86** saw the need for a campus-wide approach to prioritizing student wellbeing at MIT. He and his wife, **Sara**, are now acting to fulfill that need with a gift to the Student Wellbeing Initiatives Fund, which helped to launch the new Office of Student Wellbeing in the Division of Student Life.

"By growing in their wholeness as persons, students become better professionals, better people, and better able to contribute to society," Ricardo says.

The couple is supporting the development of the Wellbeing Pathway, a framework that will guide students in caring for their minds and bodies, fostering meaningful relationships, and clarifying their purpose at MIT and beyond. The pathway includes programs for new students and peer support training for sophomores, juniors, seniors, and graduate students. The pathway also provides resources to engage faculty in practices that prioritize wellbeing in academics.

"We hope that...effective student wellness programs spread throughout higher education."

"We hope these activities become part and parcel of MIT and its culture," says Sara.

Spreading these practices within and beyond MIT, the new Jenez Wellbeing Graduate Student Internship brings a graduate student from another institution to MIT each year to develop and deliver new student wellness programs, benefitting both institutions. "MIT sets the standard in educational excellence," says Ricardo. "Where MIT leads, other institutions follow. We hope that with MIT's leadership, effective student wellness programs spread throughout higher education." —Susan Saccoccia

Donor Spotlight

"Teachers are working incredibly hard. Creating resources that support them is very important."

"My passion has always been education and children," says **Julia Casady**, cofounder with her husband, **Mark**, of the One Step Forward Education Foundation, a proud funder of MIT's pK–12 Action Group within MIT Open Learning. Casady's commitment to education stems from her experiences as a teacher, a mother of four, a volunteer, and a grant maker advancing the best teaching and learning.

The pK–12 Action Group brings MIT's hands-on learning approach to pre-kindergarten through grade 12 (pK–12) learners and teachers around the world. The effort, Casady says, highlights characteristic MIT strengths: work that is sustainable, entrepreneurial, and global in outlook. During the pandemic, she notes, MIT Open Learning has helped meet unprecedented needs in digital learning, with a focus on equity and accessibility. The pK–12 Action Group "also does a great job enriching existing programs," says Casady, such as in schools in Massachusetts, and around the country, where tools developed at MIT help teachers to encourage students' interests in science. "Teachers are working incredibly hard. Creating resources that support them is very important to me."

Casady is confident that her foundation's support of the MIT pK–12 Action Group can make a difference because MIT reaches a worldwide network and the group's work is exceptional. The challenges in 21st-century education are steep, says Casady, and "MIT really rises to the occasion." —Kris Willcox

Donor Spotlight

"PKG's model ensures that students engage in substantive work."

John Wasson SM '86 and his wife, **Gina**, support MIT's Priscilla King Gray (PKG) Public Service Center because it extends student learning beyond the classroom through social impact internships and employment opportunities.

The Wassons' support has enabled the PKG Center to keep up with high growth in student demand during the Covid-19 pandemic. Over the past year, hundreds of students took part in its programs.

"Students see how their engineering and science talents can help address pressing social and economic challenges," says Wasson, chairman and CEO of ICF, a global consulting company serving such sectors as energy, the environment, and public health. "They work in teams, collaborate, and gain cross-disciplinary skills while working in partnership with diverse communities. What they learn can last a lifetime."

Wasson speaks from experience. While he was a graduate student at MIT, Wasson took an internship at the Conservation Law Foundation, an environmental advocacy organization. "I learned a lot by tackling real-world issues," he says, which is why he is such a fan of PKG internships. "Students see they have an impact, and this transforms their college experience."

The PKG Center's partnerships with nonprofits, as well as government organizations, social enterprises, and for-profits, also benefits host organizations, Wasson adds. "PKG's model ensures that students engage in substantive work. And nonprofits get to tap the talents of MIT students, a resource few can access on their own." —Susan Saccoccia

(↗)
TRANSFORMING LEARNING AND TEACHING AT MIT AND BEYOND
betterworld.mit.edu/learning-teaching

Championing Healthy Living

Athletics programs promote leadership, teamwork, resilience

The Department of Athletics, Physical Education and Recreation (DAPER) provides MIT students with world-class facilities and instruction for an extraordinary range of athletic endeavors, including 33 varsity teams and 25 unique types of instruction.

"Participation in physical activity and athletics serves as an opportunity for our student-athletes to develop essential lifelong skills in leadership, teamwork, and resilience," says G. Anthony Grant, the director of athletics and DAPER department head, noting that DAPER's facilities see nearly 900,000 individual recreational visits over the course of a typical year. "More importantly, participation improves students' overall mental health and provides much-needed balance to the academic rigors of the Institute."

Grant

With enthusiastic support from MIT's alumni and friends, DAPER has expanded its footprint over the last decade to enhance the entire student-athlete experience, updating facilities and adding new programs that encourage leadership and promote wellness. "The significant evolution and growth within DAPER in recent years complements MIT's commitment to fostering an environment of healthy living and well-being, while preparing our students to change the world," Grant says. —Jason Ruback

Commending and Recruiting Top Coaches

Walter Alessi retired in 2017 after coaching MIT Men's Lacrosse for over four decades. Alessi set the school record with 288 career wins and was named conference coach of the year 10 times. To celebrate Alessi's legacy as a beloved leader of generations of student-athletes, DAPER, with the help of many alumni and parents, endowed the head coach position, which helped recruit Alessi's successor, Tyler O'Keefe. "I am honored to follow in Coach Alessi's footsteps and build on the foundation and strong culture he established," says O'Keefe, who has led the Engineers to playoff appearances in both full seasons he has coached.

A New Home for MIT Crew

"One of my favorite moments all year was our first meeting in the newly renovated boathouse," says Holly Metcalf, head coach of MIT Women's Openweight Crew. "The look on each woman's face was that of disbelief, exquisite joy, and pride that this was the team's new rowing home." The multiyear project, completed in spring 2021, modernized the 22,000-gross-square-foot facility, now known as the Richard J. Resch Boathouse, and will improve the practice and competition experience for all four MIT Crew varsity teams as well as students using the rowing machines (known as ergs) for recreation. "The huge windows, larger balcony, newer boats, bigger erg rooms, new ergs, huge weight room, student study space, historical photos… everything is super nice," says PhD student Ben Koenig '21 of MIT Men's Heavyweight Crew. "It's really remarkable."

A Faster, Safer Surface for MIT Track and Field

In 2016, MIT's freshly updated outdoor track and field facilities got a new name—the Sherie and Don (1961) Morrison Track—and a new Olympic-caliber Beynon BSS 2000 rubber surface to reduce impact and improve player safety and performance. "The outdoor track and field facility is truly outstanding," said J. J. Hunter, the new director of MIT Track and Field and Cross Country. "The upgrades raised its status as a championship-level venue." MIT's outdoor programs have since earned six conference titles and four New England Division III Championships.

New Balance in Gymnastics

Long a trailblazing student club, MIT Gymnastics promotes inclusivity while competing in a sport long defined by exclusive men-only or women-only events. "The men's and women's MIT Gymnastics Club teams always allowed and encouraged team members to train and compete in any event, regardless of gender identity," says club president Jess Knapp '22. Recently, the men's and women's teams merged to create a more open and welcoming community for all. "By combining into MIT Gymnastics, we are removing potential gender-based barriers to participation in the sport we love."

Getting Student-Athletes Rehabbed and Ready

While injuries can become an unfortunate reality for any athlete, Tom Cronan, the Walter C. Price '70 Family Director of Sports Medicine, works to keep student-athletes healthy. "We are steadfast in our commitment to providing quality sports medicine health care," says Cronan, who has helped MIT Sports Medicine grow its staff to nine certified athletic trainers. "MIT is blessed with highly skilled, incredibly experienced, and genuinely kind individuals who keep our athletic programs running—literally," says graduate student Liam Ackerman '21, pictured, of MIT Track and Field.

Inspiring Authentic Leadership

DAPER launched the Levitch Leadership Laboratory (L^3) in 2018—a collaboration between the Gordon-MIT Engineering Leadership Program, MIT Sloan School of Management, and Student Activities Office—to help varsity team captains hone leadership skills. Sara Fernandez '23 of MIT Women's Tennis says, "L^3 consistently reminded me to prioritize my values. Communicating to my teammates that I value an uplifting environment, honest constructive criticism, and a high work ethic really allowed me to bring my personal standards for life into the context of sports."

From left: Former MIT women's basketball head coach Sonia Raman; former WNBA star Chamique Holdsclaw; and the David H. Koch '62 Head Coach of men's basketball, Larry Anderson, at a leadership event.

PHOTOS: COURTESY OF DAPER

Spectrum

600 Memorial Drive W98-300
Cambridge, MA 02139-4822

spectrum.mit.edu
betterworld.mit.edu
@MIT_Spectrum
facebook.com/Spectrum.MIT

GET A GRIP!

Tara Boroushaki SM '21, left, a PhD student at the MIT Media Lab, works with Laura Dodds '21, a grad student in electrical engineering and computer science, to adjust RFusion, a robotic arm that fuses radio frequency signals from an antenna with visual input from a camera to locate and retrieve items such as this Tim the Beaver toy. The technology, developed in the interdisciplinary Signal Kinetics lab, works even if the item is buried under a pile of other objects.

PHOTO: GRETCHEN ERTL