

Massachusetts Institute of Technology  
Spring 2023

# Spectrum



MOVEMENT



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## Spring 2023

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The Office of Resource Development gratefully acknowledges the leadership of the MIT Corporation.



The Stratton Student Center closed in February 2023 for a few months of renovations, including this fourth-floor dance and movement space (shown in an artistic rendering) and other upgrades throughout. Learn more on page 11.

IMAGE: DONGIK LEE INFORMED BY C&J KATZ STUDIO

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### FRONT COVER

Kaelyn Dunnell '25 dances in the MIT.nano Immersion Lab, where researchers use motion-capture cameras and sensors to gain new insights into human movement.

PHOTO: KEN RICHARDSON

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“After living in one community for 30 years, I’m a recent transplant to Cambridge—and I’ve found the experience to be incredibly energizing. Even from the outside, one senses the Institute’s intensity. Now that I’m here, I see for myself, and I love what I see: MIT never stops moving.”

**Sally Kornbluth**  
MIT President



In a scene from *The Conquered*, Jane, played by Danielle Skraastad, struggles to reconcile her memories with a past she no longer trusts to be her own.

PHOTO: SIMON SIMARD

*The Conquered* is presented as a live film—using three cameras and a live mix—with microphones amplifying the performers' voices.

**900**

students each  
year take  
theater  
classes.

“Theater has had to reconcile itself to what technology makes possible,” says Ken Urban, Senior Lecturer and Head of Dramatic Writing in Music and Theater Arts.

The tech-friendly, 180-seat black box theater is a showpiece of MIT’s Theater Arts Building (W97), which opened in 2017 on Vassar Street.

## Performance Tech

“When I teach playwriting, my students often are interested in writing about how technology impacts the lives of their characters,” says Ken Urban, senior lecturer and head of dramatic writing in the Music and Theater Arts program at MIT.

But Zoom and other defining technologies of the pandemic era have changed the “landscape of being a writer for theater,” he says.

“Theater has had to reconcile itself to what technology makes possible, such as streaming plays, writing works for virtual spaces, and using AI to generate dialogue,” Urban says. “Theater also provides what other media cannot: the experience of communal viewing in a shared space.”

Some 900 students a year take classes in theater at MIT, with performance and studio course offerings ranging from the traditional to the very avant-garde, according to Jay Scheib, the Class of 1949 Professor of Music and Theater Arts.

Innovations in neurotechnology influenced *The Conquered*, written by Urban and directed by Scheib, which was performed as a work in progress on campus at the end of 2022 with support from the MIT Center for Art, Science & Technology.

“The science that inspired the piece, a neural device that aids people with epilepsy, has been described by some implant recipients as giving a feeling of ‘someone inside their head,’” Urban says. “I transformed this into a narrative device to explore ethical issues: What does it mean to forget? How does it relate to questions of forgiveness and justice?”

“We presented it as a live film, using three cameras and doing a live mix, with microphones amplifying the performers’ voices,” Scheib says. “We weren’t actually using neurotechnology. That would be my preference, though I don’t know what that would look like. Most actors are like, ‘Brain implants? Not so sure,’” he adds, jokingly.

Looking ahead, Scheib is integrating augmented reality into his new staging of Richard Wagner’s opera *Parsifal*, which he will premiere at the Bayreuth Festival in Germany in July 2023.

Meanwhile, Urban and dance lecturer Dan Safer are collaborating with students on a dance theater piece, *Slow Violence*. “It will take place in a series of hotel rooms,” says Urban, whose band, Occurrence, will perform live. “The interplay of live and prerecorded music and projections, alongside more traditional sets, costumes, and lights, is a hallmark of theater at MIT.”

—Mark Sullivan

# Leader, Know Thyself

Class in the Daniel J. Riccio Graduate Engineering Leadership Program asks students to look inward to lead outward

TITLE

6.9280/16.9900/15.6740:  
Leading Creative Teams

INSTRUCTOR

David Niño

Senior Lecturer, Bernard M. Gordon-MIT  
Engineering Leadership Program



Niño: “A leader isn’t just somebody who stands alone at the top of a hill and delivers fire-breathing speeches. Leadership is something people do together. Anyone who has valuable insights into how to solve important problems can exercise leadership.”

Mittal: “One of the most important parts of becoming a good leader is to know yourself first. If you cannot manage yourself, you cannot manage anyone else.”

FROM THE CATALOG

This class prepares MIT graduate students for **future leadership** positions in engineering and technology environments by building a foundation of relevant capabilities. Grounded in research and theory, the class focuses on practical leadership skills and how they can be **learned, developed, and applied** to group situations in creative contexts. Examples of these contexts include project teams delivering new technologies, decision-making teams solving challenging problems, and research teams building new forms of knowledge. The course is offered through the newly named Daniel J. Riccio Graduate Engineering Leadership Program (see story at right).

CLASS MOTTO: KNOW THYSELF, BUILD EFFECTIVE TEAMS

Leading Creative Teams develops each student’s potential to become an insightful leader of teams. A semester through line focusing on **self-awareness** elucidates how students can achieve that goal by better understanding themselves, their relationships, and their collective vision.

The key self-discovery assignment is an autobiographical paper that asks students to discuss formative moments from their life and career histories and work through how these contributed to who they are today. They are required to solicit only positive feedback from 10 to 15 people to understand **how others view them**, and then describe in the paper how hearing those views affected their self-perception. Students also use this information to develop a vision of “who they can become.”

The exercise is backed by research indicating that a deeper understanding of our qualities improves team building and relations in the workplace.

Rishabh Mittal SM '20, PhD '23, Department of Electrical Engineering and Computer Science: “I had a lot of preconceptions about what leadership, management, and negotiation is about. As we went through the class, I understood that these are skills that anyone can develop.”

Mittal: “I never believed that I was making an impact in people’s lives. It was quite empowering to hear how people felt about me.”

Lee: “I was surprised about how my empathy, when it comes to my interactions with my former workers, has positively shaped their viewpoint of my work.”



“We can learn about our strengths and our virtues and the unique talents that we have, which can help motivate us to seek out the kinds of problems we can solve and engage the people that can help us,” says Niño.

Dynamic and visionary thinkers should ensure that pragmatists are included in their teams, for example. Or, introverts should build teams with complimentary extroverts.

Students also learn that conflicts are almost inevitable in teams and can be resolved through skilled and honest dialogue.

“A lot of conflicts come from confusion and misunderstandings,” says Chiwon Lee, a second-year Integrated Design and Management master’s student. “Ask open questions and use active listening and make sure that you’re focusing on the mutual gain from the conversation rather than assuming the intention. It’s a very logical way and a good framework to have when it comes to resolving conflict.”

From Action Learning projects in classes at the MIT Sloan School of Management to negotiating postgraduation salaries, these teachings are already helping students **grow as confident leaders**.

“As a student with 10 years of industry experience, I have often reflected on how I could have applied the learnings from this class to situations and conflicts I experienced early in my career,” says geologist Warren Anderson, a fellow in the System Design and Management master’s program jointly offered by the MIT School of Engineering and MIT Sloan. “This course allows you to reflect on your personal leadership style and provides the tools to communicate effectively with your team.”

All this self-reflection helps students identify their ethical codes of conduct, and a series of class exercises encourages them to stand up for what they believe in within the workplace and to not compromise on issues that are important to them.

“When I say I hope our students will become good leaders in the future, I mean that in a very meaningful way—that they have a sense of what their ethical values are,” says Niño. “That’s valuable in the larger context of an engineering education, that students are mindful of how what they do impacts others and impacts society as well.”

—Stephanie M. McPherson SM '11

Lee: “I’ve been able to apply my class learnings directly to conflict situations for team projects that are for almost all courses that I’ve been in.”

Students in the class Leading Creative Teams collaborate on experiential learning activities that build self-awareness and communication skills.  
PHOTOS: M. SCOTT BRAUER

## \$10M Gift Supports Mission to Develop Next-Generation Tech Leaders

In October 2022, MIT announced a \$10 million gift from Daniel J. Riccio to expand and name the Graduate Engineering Leadership Program (GradEL) in the MIT School of Engineering.

The program aims to help develop engineers who will go on to inspire and guide teams throughout their careers. “Those types of skills are essential to successful engineers,” says Riccio, vice president of engineering at Apple, who also serves on the advisory board of the Bernard M. Gordon-MIT Engineering Leadership Program (GEL).

“It is true not just of Apple but of many innovative companies that we are limited not by ideas or by money but by having enough effective engineering leadership to bring complex, innovative products to market,” Riccio says. “I want to do something about it.”

The success of GEL, which was established in 2007 and serves some 150 undergraduates each year, led the School of Engineering four years ago to launch GradEL—now the Daniel J. Riccio Graduate Engineering

Leadership Program—a series of classes and workshops that culminates in a graduate certificate in technical leadership.

“The gift from Daniel Riccio will allow the graduate program to grow from a ‘scrappy startup’ to the type of sustainable program that characterizes the longer-running undergraduate program,” says Reza Rahaman SM '85, PhD '89, the Bernard M. Gordon Managing Director of the School of Engineering Technical Leadership and Communication Programs.

Anantha Chandrakasan, dean of the School of Engineering and the Vannevar Bush Professor of Electrical Engineering and Computer Science, says, “I am extremely grateful for this gift and excited about the potential it provides to the future of the Daniel J. Riccio Graduate Engineering Leadership Program.”

*A version of this story was originally published in MIT News.*



MO



On a campus full of people not known for standing still, “movement” manifests itself in many ways across MIT—from biomechanics and predictive modeling to collective action and economic mobility to transportation and quantum spin. No matter their area of focus, our faculty, students, and staff will always find a way to drive things forward.

# MOVEMENT

Kaelyn Dunnell '25 executes a dance move known as a “stag jump” while MIT.nano researchers track her movements. See story on page 14.

PHOTO: KEN RICHARDSON

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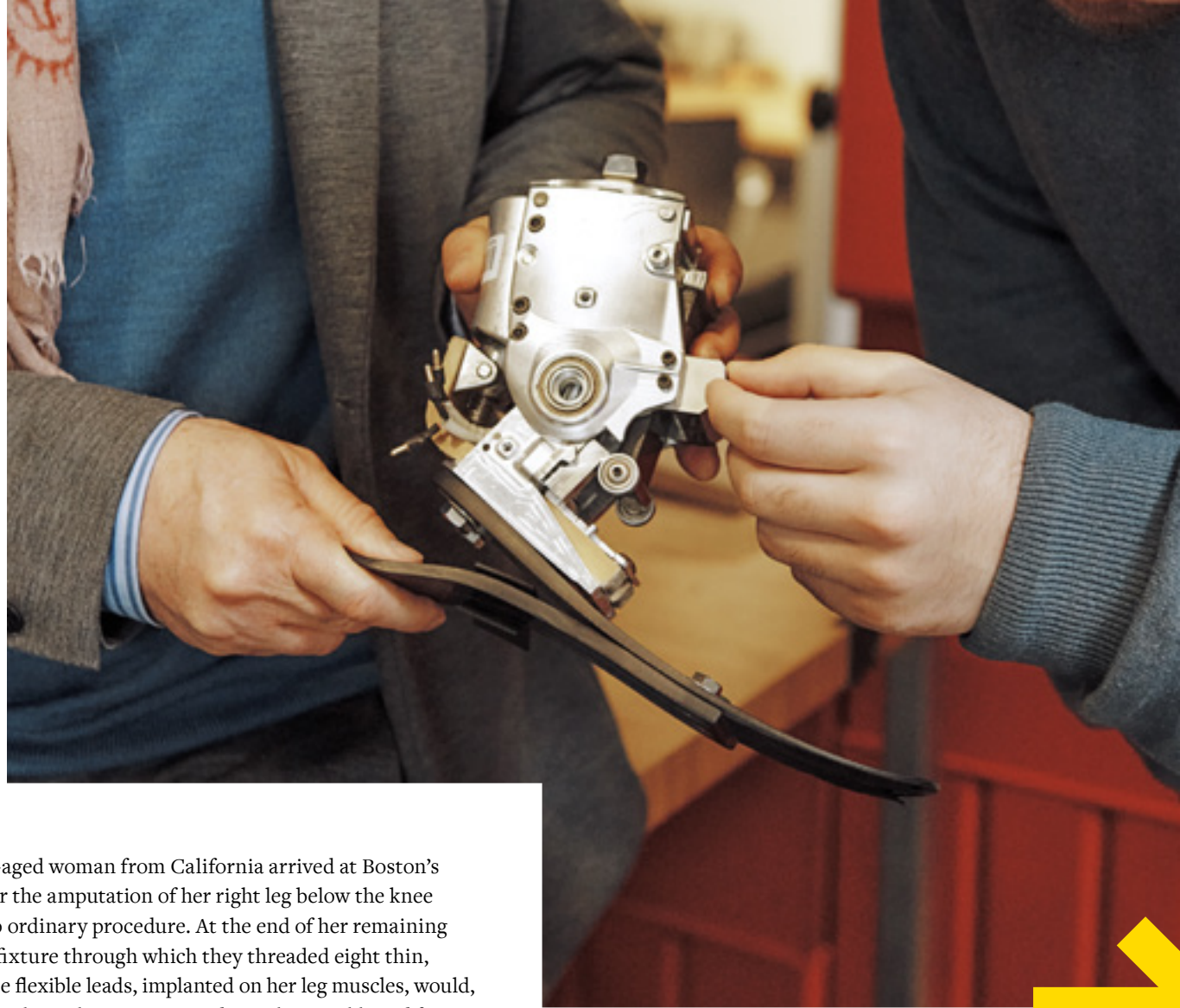


# Building Better Bodies

At the K. Lisa Yang Center for Bionics, researchers develop technologies to ease pain and transcend human limitations

K. Lisa Yang Center for Bionics codirector Hugh Herr SM '93, left, and graduate student Christopher Shallal are working to return mobility to people disabled by disease or physical trauma.

PHOTOS: TONY LUONG



In early December 2022, a middle-aged woman from California arrived at Boston's Brigham and Women's Hospital for the amputation of her right leg below the knee following an accident. This was no ordinary procedure. At the end of her remaining leg, surgeons attached a titanium fixture through which they threaded eight thin, electrically conductive wires. These flexible leads, implanted on her leg muscles, would, in the coming months, connect to a robotic, battery-powered prosthetic ankle and foot.

The goal of this unprecedented surgery, driven by MIT researchers from the K. Lisa Yang Center for Bionics at MIT, was the restoration of near-natural function to the patient, enabling her to sense and control the position and motion of her ankle and foot—even with her eyes closed.

"The brain knows exactly how to control the limb, and it doesn't matter whether it is flesh and bone or made of titanium, silicon, and carbon composite," says Hugh Herr SM '93, professor of media arts and sciences, head of the MIT Media Lab's Biomechatronics Group, codirector of the Yang Center, and an associate member of MIT's McGovern Institute for Brain Research.

For Herr, in attendance during that long day, the surgery represented a critical milestone in a decades-long mission to develop technologies returning mobility to people disabled by disease or physical trauma. His research combines a dizzying range of disciplines—electrical, mechanical, tissue, and biomedical engineering, as well as neuroscience and robotics—and has yielded pathbreaking results. Herr's more than 100 patents include a computer-controlled knee and powered ankle-foot prosthesis and have enabled thousands of people around the world to live more on their own terms, including Herr.

### Surmounting catastrophe

For much of Herr's life, "go" meant "up."

"Starting when I was eight, I developed an extraordinary passion, an absolute obsession, for climbing; it's all I thought about in life," says Herr. He aspired "to be the best climber in the world," a goal he nearly achieved in his teenage years, enthralled by the "purity" of ascending mountains ropeless and solo in record times, by "a vertical dance, a balance between physicality and mind control."

At 17, Herr became disoriented while climbing New Hampshire's Mt. Washington during a blizzard. Days in the cold permanently damaged his legs, which had to be amputated below his knees. His rescue cost another man's life, and Herr was despondent, disappointed in himself, and fearful for his future.

Then, following months of rehabilitation, he felt compelled to test himself. His first

weekend home, when he couldn't walk without canes and crutches, he headed back to the mountains. "I hobbled to the base of this vertical cliff and started ascending," he recalls. "It brought me joy to realize that I was still me, the same person."

But he also recognized that as a person with amputated limbs, he faced severe disadvantages. "Society doesn't look kindly on people with unusual bodies; we are viewed as crippled and weak, and that did not sit well with me." Unable to tolerate both the new physical and social constraints on his life, Herr determined to view his disability not as a loss but as an opportunity. "I think the rage was the catapult that led me to do something that was without precedent," he says.

### Lifelike limb

On hand in the surgical theater in December was a member of Herr's Biomechatronics Group for whom the bionic limb procedure also held special resonance. Christopher Shallal, a second-year graduate student in the Harvard-MIT Health Sciences and Technology program who received bilateral lower limb amputations at birth, worked alongside surgeon Matthew Carty testing the electric leads before implantation in the patient. Shallal found this, his first direct involvement with a reconstruction surgery, deeply fulfilling.

"Ever since I was a kid, I've wanted to do medicine plus engineering," says Shallal. "I'm really excited to work on this bionic limb reconstruction, which will probably be one of the most advanced systems yet in terms of neural interfacing and control, with a far greater range of motion possible."



Herr and Shallal are working on a next-generation, biomimetic limb with implanted sensors that can relay signals between the external prosthesis and muscles in the remaining limb.

PHOTO: TONY LUONG

will be able to “feel” their prosthetic leg step onto the ground. This sensory capability is the holy grail for persons with major limb loss. After recovery from her surgery, the woman from California will be wearing Herr’s latest state-of-the-art prosthetic system in the lab.

### ‘Tinkering’ with the body

Not all artificial limbs emulate those that humans are born with. “You can make them however you want, swapping them in and out depending on what you want to do, and they can take you anywhere,” Herr says. Committed to extreme climbing even after his accident, Herr came up with special limbs that became a commercial hit early in his career. His designs made it possible for someone with amputated legs to run and dance.

But he also knew the day-to-day discomfort of navigating on flatter earth with most prostheses. He won his first patent during his senior year of college for a fluid-controlled socket attachment designed to reduce the pain of walking. Growing up in a Mennonite family skilled in handcrafting things they needed, and in a larger community that was disdainful of technology, Herr says he had “difficulty trusting machines.” Yet by the time he began his master’s program at MIT, intent on liberating persons with limb amputation to live more fully in the world, he had embraced the tools of science and engineering as the means to this end.

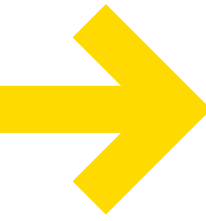
For Shallal, Herr was an early icon, and his inventions and climbing exploits served as inspiration. “I’d known about Hugh since middle school; he was famous among those with amputations,” he says. “As a kid, I liked tinkering with things, and I kind of saw my body as a canvas, a place where I could explore different boundaries and expand possibilities for myself and others with amputations.” In school, Shallal sometimes encountered resistance to his prostheses. “People would say I couldn’t do certain things, like running and playing different sports, and I found these barriers frustrating,” he says. “I did things in my own way and didn’t want people to pity me.”

In fact, Shallal felt he could do some things better than his peers. In high school, he used a 3-D printer to make a mobile phone charger case he could plug into his prosthesis. “As a kid, I would wear long pants to hide my legs, but as the technology got cooler, I started wearing shorts,” he says. “I got comfortable and liked kind of showing off my legs.”

### Global impact

December’s surgery was the first phase in the bionic limb project. Shallal will be following up with the patient over many months, ensuring that the connections between her limb and implanted sensors function and provide appropriate sensorimotor data for the built-in processor. Research on this and other patients to determine the impact of these limbs on gait and ease of managing slopes, for instance, will form the basis for Shallal’s dissertation.

“I want to be in the business of designing not more and more powerful tools but designing new bodies,” says Hugh Herr.



Like other Herr lab designs, the new prosthesis features onboard, battery-powered propulsion, microprocessors, and tunable actuators. But this next-generation, biomimetic limb represents a major leap forward, replacing electrodes sited on a patient’s skin, subject to sweat and other environmental threats, with implanted sensors that can relay signals between the external prosthesis and muscles in the remaining limb.

This system takes advantage of a breakthrough technique invented several years ago by the Herr lab called CMI (for cutaneous mechanoneural interface), which constructs muscle-skin-nerve bundles at the amputation site. Muscle actuators controlled by computers on board the external prosthesis apply forces on skin cells implanted within the amputated residuum when a person with amputation touches an object with their prosthesis.

With CMI and electric leads connecting the prosthesis to these muscle actuators within the residual limb, the researchers hypothesize that a person with an amputation

“After graduation, I’d be really interested in translating technology out of the lab, maybe doing a startup related to neural interfacing technology,” he says. “I watched *Inspector Gadget* on television when I was a kid. Making the tool you need at the time you need it to fix problems would be my dream.”

Herr will be overseeing Shallal’s work, as well as a suite of research efforts propelled by other graduate students, postdocs, and research scientists that together promise to strengthen the technology behind this generation of biomimetic prostheses.

One example: devising an innovative method for measuring muscle length and velocity with tiny implanted magnets. In work published in November 2022, researchers including Herr; project lead Cameron Taylor SM ’16, PhD ’20, a research associate in the Biomechanics Group; and Brown University partners demonstrated that this new tool, magnetomicrometry, yields the kind of high-resolution data necessary for even more precise bionic limb control. The Herr lab awaits FDA approval on human implantation of the magnetic beads.

These intertwined initiatives are central to the ambitious mission of the K. Lisa Yang Center for Bionics, established with a \$24 million gift from Yang in 2021 to tackle transformative bionic interventions to address an extensive range of human limitations.

Herr is committed to making the broadest possible impact with his technologies. “Shoes and braces hurt, so my group is developing the science of comfort—designing mechanical parts that attach to the body and transfer loads without causing pain.” These inventions may prove useful not just to people living with amputation but to patients suffering from arthritis or other diseases affecting muscles, joints, and bones, whether in lower limbs or arms and hands.

The Yang Center aims to make prosthetic and orthotic devices more accessible globally, so Herr’s group is ramping up services in Sierra Leone, where civil war left tens of thousands missing limbs after devastating machete attacks (see story on page 12). “We’re educating clinicians, helping with supply chain infrastructure, introducing novel assistive technology, and developing mobile delivery platforms,” he says.

In the end, says Herr, “I want to be in the business of designing not more and more powerful tools but designing new bodies.” Herr uses himself as an example: “I walk on two very powerful robots, but they’re not linked to my skeleton, or to my brain, so when I walk it feels like I’m on powerful machines that are not me. What I want is such a marriage between human physiology and electromechanics that a person feels at one with the synthetic, designed content of their body.”

—Leda Zimmerman

## Moving MIT Forward

The opening words of MIT’s mission statement—“to advance knowledge”—convey a sense of purposeful momentum that is etched into MIT’s DNA. **JULIE A. LUCAS**, the Institute’s vice president for resource development, talks about how the generosity and engagement of the extended MIT community, especially in support of initiatives such as the K. Lisa Yang Center for Bionics and campus spaces like the Stratton Student Center, help keep the Institute’s faculty, students, and staff moving forward.

### What makes the K. Lisa Yang Center for Bionics such an exciting addition to MIT?

The Yang Center has a powerful objective: to create transformational bionic interventions for people with disabilities. You only need read the inspiring story starting on page 8 to understand the vast, life-changing potential of this work. The center is also a terrific showcase for two of MIT’s most distinguishing traits: interdisciplinary research and external collaboration. Working together, MIT faculty

from the Schools of Science, Engineering, and Architecture and Planning are consulting with clinical and surgical experts at Harvard Medical School to ensure that new assistive technologies can be tested rapidly and put within reach of people in need, including those in traditionally underserved communities.

### How did the center come about?

The center was made possible by a gift to MIT from philanthropist Lisa Yang. Her previous gifts to the Institute have enabled the establishment of the K. Lisa Yang and Hock E. Tan Center for Molecular Therapeutics in Neuroscience and the K. Lisa Yang Brain-Body Center, as well as other programs in support of faculty and students. Lisa’s commitment to improving human health for the benefit of all



has transformed research at the Institute. We are grateful for her support, as we are for gifts of all sizes, which are fundamental to accelerating innovation and discovery at MIT.

### Speaking of movement, one of the places at MIT that rarely stops is the Stratton Student Center. What’s next for this crucial spot on campus?

Thanks to the support of a number of MIT alumni and friends, a renovation of the student center is moving forward, and we are thrilled by the energy it will bring to this campus landmark and, by extension, to our community. The numerous improvements include the creation of a Wellbeing Lab and a redesign of the central staircase that will open the building’s atrium. Fourth-floor updates include spaces for dance and movement activities such as yoga, and there will be enhanced lounges and gathering spaces throughout the building where students can congregate, rest, and recharge. We are continuing to raise funds for the renovation and are looking forward to fall 2023 when we anticipate sharing the updated Student Center with everyone.

# Increasing Prosthetics Access

**PhD student Francesca Riccio-Ackerman works to build more equitable care worldwide**

In Sierra Leone, war and illness have left up to 40,000 people requiring orthotics and prosthetics services, but there is a profound lack of access to specialized care, says Francesca Riccio-Ackerman, a biomedical engineer and PhD student studying health equity and health systems. There is just one fully certified prosthetist available for the thousands of patients in the African nation who are living with amputation, she notes. The ideal number is one for every 250, according to the World Health Organization and the International Society of Orthotics and Prosthetics.

The data point is significant for Riccio-Ackerman, who conducts research in the MIT Media Lab's Biomechatronics Group and in the K. Lisa Yang Center for Bionics, both of which aim to improve translation of assistive technologies to people with disabilities. "We're really focused on improving and augmenting human mobility," she says. For Riccio-Ackerman, part of the quest to improve human mobility means ensuring that the people who need access to prosthetic care can get it—for the duration of their lives.

In September 2021, the Yang Center provided funding for Riccio-Ackerman to travel to Sierra Leone, where she witnessed the lingering physical effects of a brutal decade-long civil war that ended in 2002. Prosthetic and orthotic care in the country, where a vast number of patients are also disabled by untreated polio or diabetes, has become more elusive, she says, as global media attention on the war's aftermath has subsided. "People with amputation need low-level, consistent care for years. There really needs to be a long-term investment in improving this."

Through the Yang Center and supported by a fellowship from the new MIT Morningside Academy for Design, Riccio-Ackerman is designing and building a sustainable care and delivery model in Sierra Leone that aims to multiply the production of prosthetic limbs and strengthen the country's prosthetic sector. "[We're working] to improve access to orthotic and prosthetic services," she says.

She is also helping to establish a supply chain for prosthetic limb and orthotic brace parts and equipping clinics with machines and infrastructure to serve more patients. In January 2023, her team launched a four-year collaboration with the Sierra Leone Ministry of Health and Sanitation. One of the goals of the joint effort is to enable Sierra Leoneans to obtain professional prosthetics training, so they can care for their own community without leaving home.

## From engineering to economics

Riccio-Ackerman was drawn to issues around human mobility after witnessing her aunt suffer from rheumatoid arthritis. "My aunt was young, but she looked like she was 80 or 90. She was sick, in pain, in a wheelchair—a young spirit in an old body," she says.



PhD student Francesca Riccio-Ackerman and a technician inspect a prosthesis in Sierra Leone. Also shown: partially assembled and spare prosthetic components from a clinic in Koidu, Sierra Leone.

PHOTOS: ADIKALIE KAMARA

As a biomedical engineering undergraduate student at Florida International University, Riccio-Ackerman worked on clinical trials for neural-enabled myoelectric arms controlled by nerves in the body. She says that the technology was thrilling yet heartbreaking. She would often have to explain to patients who participated in testing that they couldn't take the devices home and that they may never be covered by insurance.

Riccio-Ackerman began asking questions: "What factors determine who gets an amputation?"

Why are we making devices that are so expensive and inaccessible?" This sense of injustice inspired her to pivot away from device design and toward a master's degree in health economics and policy at the SDA Bocconi School of Management in Milan.

She began work as a research specialist with Hugh Herr SM '93, professor of arts and sciences at the MIT Media Lab and codirector of the Yang Center, helping to study communities that were medically neglected in prosthetic care. "I knew that the devices weren't getting to the people who need them, and I didn't know if the best way to solve it was through engineering," Riccio-Ackerman explains.

While Riccio-Ackerman's PhD should be finished within three years, she's only at the beginning of her health care equity work. "We're forging ahead in Sierra Leone and thinking about translating our strategy and methodologies to other communities around the globe that could benefit," she says. "We hope to be able to do this in many, many countries in the future." —Kara Baskin

# The Marvelous Journey from A to B

Nidhi Seethapathi seeks to understand why we move the way we do

Nidhi Seethapathi was first drawn to using powerful yet simple models to understand elaborate patterns when she learned about Newton's laws of motion as a high school student in India. She was fascinated by the idea that wonderfully complex behaviors can arise from a set of objects that follow a few elementary rules.

Now an assistant professor at MIT, Seethapathi seeks to capture the intricacies of movement in the real world, using computational modeling as well as input from theory and experimentation. “[Theoretical physicist and Nobel laureate] Richard Feynman ’39 once said, ‘What I cannot create, I do not understand,’” Seethapathi says. “In that same spirit, the way I try to understand movement is by building models that move the way we do.”

## Models of locomotion in the real world

Seethapathi—who holds a shared faculty position between the Department of Brain and Cognitive Sciences and the Department of Electrical Engineering and Computer Science’s Faculty of Artificial Intelligence + Decision-Making, which is housed in the Schwarzman College of Computing and the School of Engineering—recalls a moment during her undergraduate years studying mechanical engineering in Mumbai when a professor asked

students to pick an aspect of movement to examine in detail. While most of her peers chose to analyze machines, Seethapathi selected the human hand. She was astounded by its versatility, she says, and by the number of variables, referred to by scientists as “degrees of freedom,” that are needed to characterize routine manual tasks. The assignment made her realize that she wanted to explore the diverse ways in which the entire human body can move.

Also an investigator at the McGovern Institute for Brain Research, Seethapathi pursued graduate research at The Ohio State University Movement Lab, where her goal was to identify the key elements of human locomotion. At that time, most people in the field were analyzing simple movements, she says, “but I was interested in broadening the scope of my models to include real-world behavior. Given that movement is so ubiquitous, I wondered: What can this model say about everyday life?”

After earning her PhD from Ohio State in 2018, Seethapathi continued this line of research as a postdoctoral fellow at the University of Pennsylvania. New computer vision tools to track human movement from video footage had just entered the scene, and during her time at UPenn, Seethapathi sought to expand her skillset to include computer vision and

applications to movement rehabilitation.

At MIT, Seethapathi continues to extend the range of her studies of human movement, looking at how locomotion can evolve as people grow and age, and how it can adapt to anatomical changes and even adjust to shifts in weather, which can alter ground conditions. Her investigations now encompass other species as part of an effort to determine how creatures with different morphologies and habitats regulate their movements.

The models Seethapathi and her team create make predictions about human movements that can later be verified or refuted by empirical tests. While relatively simple experiments can be carried out on treadmills, her group is developing measurement systems incorporating wearable sensors and video-based sensing to measure movement data that have traditionally been hard to obtain outside the laboratory.

Although Seethapathi says she is primarily driven to uncover the fundamental principles that govern movement behavior, she believes her work also has practical applications.

“When people are treated for a movement disorder, the goal is to impact their movements in the real world,” she says. “We can use our predictive models to see how a particular intervention will affect a person’s trajectory. The hope is that our models can help put the individual on the right track to recovery as early as possible.” —Steve Nadis

## (7)

### ROBOTS TO HELP WITH HEALING

“We’re using [simulated] robots to understand how humans are moving and eventually to explain any kind of movement,” says PhD student Wei-Chen (Eric) Wang SM ’22, who works in Seethapathi’s lab.

READ ABOUT HIS WORK AT  
[spectrum.mit.edu/wang](https://spectrum.mit.edu/wang)

Nidhi Seethapathi uses computational modeling in her study of human movement.

PHOTO: STEPH STEVENS





# Discovery in Motion

In the MIT.nano Immersion Lab, capturing the movements of dancers has wide applications

In the autumn of 2011, when Praneeth Namburi PhD '16 was a graduate student at MIT, he recalls “stumbling into a room full of people dancing.” Which is how Namburi took his first lesson with the MIT Ballroom Dance Team—by accident. “The instructor just put me in front of a partner,” he says. Yet despite his serendipitous introduction to the sport, Namburi chose to go back week after week, first as a respite from the rigors of his degree in experimental neuroscience and then, when he got deeper into it, “as a way of exploring and understanding how my body works.”

In 2018, returning from a ballroom competition at Columbia University, Namburi experienced a sudden flash of insight inspired by all his time practicing and learning dance. In that moment, he understood that to dance is to move one’s body as a whole—as a single, unbroken form. Namburi logged into Amazon and bought a few motion sensors to stick to his body as he danced. By looking at the data from those sensors before and after learning a new routine, Namburi gained a quantitative means of describing his mastery of movement. It got him thinking about whether he could use that information to help others learn. “Everybody has the potential,” he says. “Most people just haven’t discovered it yet.”

Graduate student Roger Pallares Lopez views sensors placed on dancer Kaelyn Dunnell '25 from a monitor in the MIT.nano Immersion Lab.

PHOTOS: KEN RICHARDSON

Today, Namburi is a research scientist at the MIT.nano Immersion Lab, a shared, central facility housed within the Lisa T. Su Building that enables research visualizing and interacting with large, multidimensional data sets. Projects span departments and disciplines, ranging from 3-D content development to hardware design to human-subject research, and bringing together engineers, scientists, artists, and athletes.

One project that bridges the physical and digital worlds uses virtual reality (VR) simulations to train people to fabricate computer chips and semiconductors. This allows individuals to “visualize and interact with the tools virtually before you put them in front of something where they can hurt themselves or the equipment,” says Brian W. Anthony SM '98, PhD '06, associate director of MIT.nano and the Immersion Lab’s founding director.

In addition, the data from a single measurement from one of MIT.nano’s sophisticated characterization tools, including scanning and electron microscopes, can easily



be several terabytes. To interact with that hi-res and high-dimensional imagery, the Immersion Lab uses VR and augmented reality (AR) and massive interactive compute power to allow researchers to “blow it up to human scale” and then grab and pull at it, says Anthony. “Many of these tools have been around for a while,” notes Talis Reks, the Immersion Lab’s VR/AR gaming technologist, but he says the applications are fresh and innovative.

The lab routinely supports deep collaborations between scientists and artists. Anthony explains that “after you start to build those capabilities for training or for data interaction, it’s a set of tools now that are broadly applicable” to art, education, design, manufacturing, and dance. That’s where Namburi fits in.

### A new tool for communication and instruction

Namburi fires up a demo video filmed at a nearby production studio where several dozen motion-capture cameras hang from the ceiling, pointing downwards at a wooden floor. A coach stands beside a high-heeled dancer wearing an AR headset, her back covered with motion-tracking markers. The foxtrot music begins and as the performer dances, the coach offers encouraging words: “From the legs to the spine, from the spine to the legs. Feel the rhythm. Good, good. Be yourself.”

Meanwhile, in the headset, the dancer sees herself represented as a constellation of moving lights, corresponding to the placement of the markers on her back. “This is similar to a portable mirror,” says Namburi. “She can view the relationships between different parts of her back, as if she’s always standing behind herself.” The goal is to give the dancer-coach duo a new tool to improve communication and instruction, one that provides instantaneous, visual feedback.

The AR session stayed with the dancer, who later told Namburi she continues to imagine those glowing, moving points of light in her mind as she learns new routines. “Getting immediate feedback on whether one achieved an intended action or not,” says Namburi, “seems to be the most valuable aspect of this biofeedback tool.”

### From the dance floor to the factory floor

Anthony says that professional dancers, who strive “to get better at motion—more efficient, more smooth, more elegant,” have traits that can be helpful to people across a broad spectrum of activities. Namburi and his team used accelerometers to record dancers and other “motion experts,” such as athletes and martial artists, as they made simple reaching gestures with one arm. The researchers observed that the professionals moved more smoothly than the typical person. When individuals without motion training were recorded making the same gesture, they exhibited a characteristic shake and subtle tremor, undetectable to the naked eye.

A similar difference emerges among workers on a factory floor whose wrists were outfitted with accelerometers. Those with less experience tend to conduct their physical tasks not as smoothly and with more wobble. “The characteristics of efficient motion that we see in dance,” says Anthony, “help us understand what it means to be efficient or fatigued in other domains,” settings where worker safety and performance are important, for example. Namburi says these insights could help lead to changes in a factory’s environment or training protocol to reduce the risk of injury.

Although Namburi continues to take ballroom dancing lessons several hours each week, his work with the Immersion Lab has taught him “that we don’t necessarily know how to see movement.” That’s why, from time to time, he wires up and works through a routine on that dance floor ringed by motion-capture cameras. For Namburi, the lab is a tool “to interact with my dancing in another way”—with the power to teach the dancer inside each of us how to visualize and then control our own movement.

—Ari Daniel PhD '08

“The characteristics of efficient motion that we see in dance help us understand what it means to be efficient or fatigued in other domains,” says Brian Anthony.



Left: Immersion Lab research scientist Praneeth Namburi PhD '16, graduate student Jessica Rosendorf, and Enya Ryu '23 attach motion-tracking markers, above, to dancer Kaelyn Dunnell '25.

# The Spin Doctor

Chemist Danna Freedman designs novel molecules for possible quantum applications

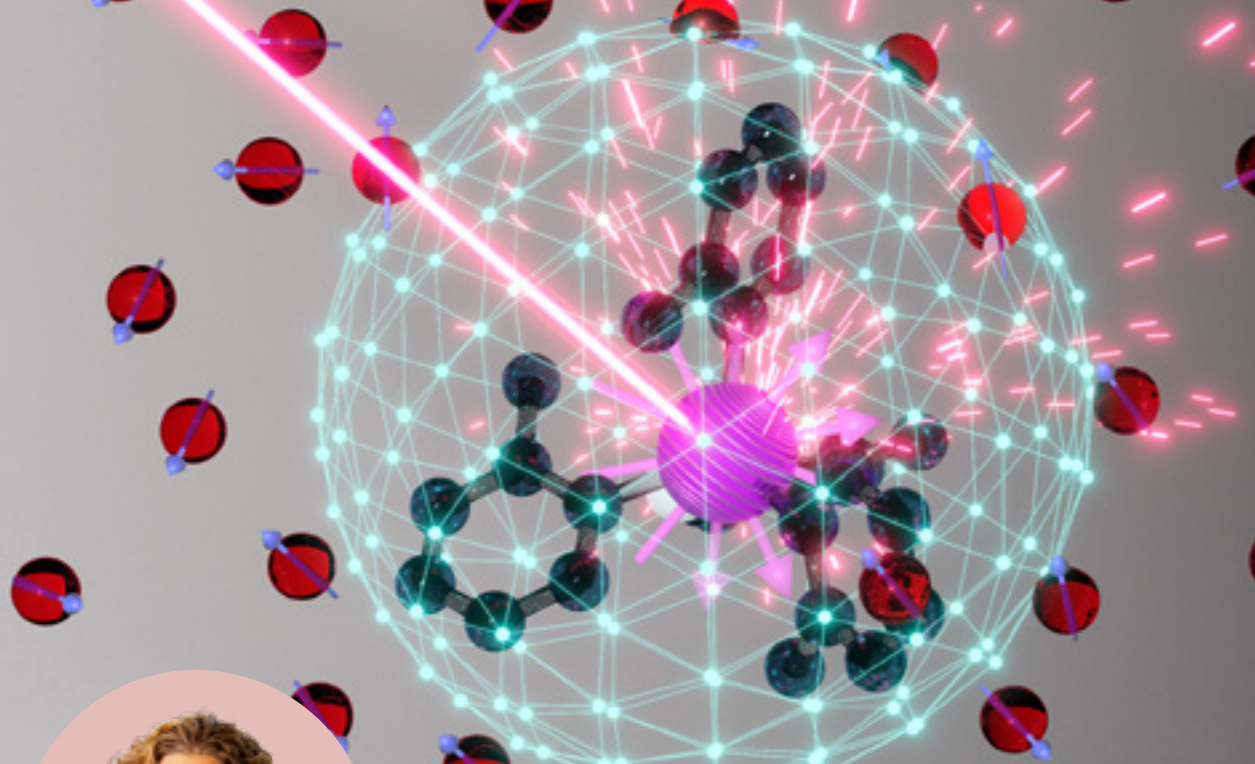


Illustration of an experiment that analyzes a molecular qubit.

IMAGE: DANIEL LAORENZA  
PHOTO: M. SCOTT BRAUER

Danna Freedman was returning to her MIT office in early September 2022 with cookies for her students when she heard the news: she had been awarded a MacArthur Fellowship, the no-strings \$800,000 prize referred to as the “genius grant.” Her lab’s groundbreaking work using synthetic chemistry to design novel molecules potentially paves the way for quantum sensing and communication applications to be conducted with a new set of tools—molecules—versus traditionally used, and intrinsically more limiting, solid-state materials.

“I was speechless. This is an incredible honor,” says Freedman, the F. G. Keyes Professor of Chemistry. “It’s acknowledgment that we’re on the right track, that we opened up a door into a real field that has real potential, not just on paper but to impact the world around us.”

Quantum mechanics is a field of physics that seeks to understand the behavior of the tiniest particles in the universe—particles that are small or smaller than atoms (including electrons, protons, and neutrons) and behave differently from larger objects, often in strange ways. The first “quantum revolution” of the 20th century led scientists to observe quantum properties and develop technologies like lasers, the transistor, GPS, magnetic resonance imaging, and semiconductors. Now, in the second quantum revolution, scientists like Freedman are seeking to harness those properties and apply them to a wide range of fields.

At the heart of this work, and one of its biggest hurdles, is the concept of electron spin, a quantum property and form of angular momentum that influences the position of electrons and nuclei in atoms and molecules. Spin can have two states but also a natural third state that’s a combination of the two, called superposition. (Think about something on Earth

existing not just in one position like up or down but in several positions all at once, or a spinning coin that is neither heads nor tails.)

Few molecules remain in this third state long enough to measure, so they have been difficult to use as building blocks for quantum technologies. Freedman, a former MIT postdoc who joined the faculty in 2021, appears to have devised a way using a bottom-up approach.

From the electron spin of certain molecules, her lab has created a new class of quantum units, or qubits, that retain superposition and can be manipulated to control quantum system properties. Their research has shown that qubits—in this case, molecules designed with a central chromium atom surrounded by four hydrocarbon molecules—could be customized for specific targets within quantum sensing and communication.

Using chemical control, Freedman says spins can be positioned in chosen orientations or separated by form (electron versus proton). Specific combinations of atoms can even be forced to interact to shed light on the nature of a chemical bond. “Chemistry enables us to make systems that are atomically precise, reproducible, and tunable,” she says.

## Next-generation information processing

Freedman is reluctant to speculate about the potential real-world applications of her research, but a next generation of molecular components could perform otherwise impossible information-

processing (sensing, communication, and measurement) tasks with an unprecedented level of specification and accuracy.

“Molecules are uniquely suited for a lot of quantum sensing applications and for quantum communication applications,” Freedman says. “You can use a molecule to put atoms exactly where you want them to be and then tune them so you can get a whole array of properties, and that combination is incredibly powerful for applications where specificity is important.”

One direction she hopes to pursue with her MacArthur grant is working with other scientists on quantum sensors, which are extremely sensitive to minuscule variations in their environment. Freedman’s lab also works on targeting emergent properties and applying extreme pressure to synthesize new materials, which could impact areas such as energy generation and transport.

## Creativity and scholarly depth

Freedman’s deep passion for her work is palpable. In high school, she taught science to 11-year-olds and worked at the local observatory running the telescope and conducting tours. That’s where she heard a guest scientist explain an alternative theory to dark matter. Now, decades later, she’s thrilled to also be collaborating on a dark matter detection project.

“I’ve been hearing about this since I was 15,” she says. “How lucky am I that I had such a long exposure.”

Freedman describes MIT as “phenomenally interdisciplinary.” Her office is near that of Peter Shor PhD ’85, the renowned mathematician and quantum computing pioneer. “This is just an inspirational place to be,” Freedman says. “There’s a lot of creativity, risk taking, and ambition, but it’s also met by a scholarly depth, which is essential.” —Pamela Ferdinand

# When Movements Topple Dictators

Barriers to democratization remain even after successful revolutions, says associate professor Mai Hassan

Social and political movements can be powerful enough to topple authoritarian regimes. “But mobilizing large numbers of people onto the streets takes collective action,” says Mai Hassan, associate professor of political science in the School of Humanities, Arts, and Social Sciences, noting that successful revolutions tap into broad, easily understood narratives and feelings that run deep among the general public. “The mantra of the Sudanese uprising in 2019 was ‘freedom, peace, and justice.’ Who doesn’t want that?”

Hassan, a social scientist examining contentious politics and collective action in autocratic regimes, also studies the barriers to democratization that follow in the aftermath. “Overthrowing a dictatorship is fundamentally different than building a lasting democracy,” she notes. People with different backgrounds may unite to oppose brutal rulers as they did in Sudan, but they usually don’t establish consensus about what should come next.

“Once an authoritarian regime is overthrown, then comes the bickering about what should replace it,” says Hassan. In the case of theocracies, some activists will expect the new government to be secular, while others might envision a less restrictive faith-based government. Some will

“Overthrowing a dictatorship is fundamentally different than building a lasting democracy,” says Mai Hassan.

advocate for a more expansive socialist and welfare state and find themselves in opposition to proponents of capitalism.

While Hassan studies several countries in Africa, she is particularly interested in Sudan, from which she and much of her extended family emigrated in the 1990s. After settling in Virginia, she frequently listened to adults talking about the political turmoil in the country they left behind, piquing her interest in history, economics, and political science.

## Social movements in the age of social media

Modern political movements, Hassan believes, may be more susceptible to the problem of competing internal objectives because today’s activists are recruited differently than in the past. While the extensive reach of social media can quickly gather protest participants to engage in collective action, the result is often a group with diverse belief systems. “If an opposition political party or deeply ingrained labor union was at the forefront of the movement,” Hassan says, “they would have built up membership for years and instilled the organization’s core beliefs in its members. It would be very clear what the post-revolution landscape they were working towards would look like.”

While information and communication technologies are useful for coordinating collective action, Hassan points out, the regime can see social media posts, too. “But dissidents are smart,” she continues. “Living in an authoritarian regime for years, they have developed intuition of how the regime is likely to respond, and they come up with clever ways to outsmart them.” Her field research has uncovered stories of activists using subversive tactics, for example, keeping the date, time, and mode of a protest the same but quietly changing the location.

This poses a challenge for researchers like Hassan who, she says, can’t rely only on publicly available data, given that sources such as social media posts might be written to mislead the regime. For her most recent paper “Coordinated Dis-coordination,” Hassan conducted more than 100 interviews and focus groups with leading activists and dissidents in and around Khartoum, the capital of Sudan, to study how dissidents used social media to coordinate among themselves while deceiving the regime.

## Building—or protecting—democratic systems

Joining a political movement in an authoritarian country can subject participants to hostility and even violence, not just from the regime but from fellow citizens. “Every authoritarian regime has some popular base of support,” says Hassan.

The recent phenomenon of election denialism in the United States, she observes, “puts into perspective how polarized the United States is if some people are willing to overthrow democratic protections just to have a government that will instill their idea of what society should look like.” She explains that when social scientists evaluate other countries for democratization potential, they examine the thinking of that nation’s powerful elites. “Do they believe that democracy is the only valid form of government? When we turn that criterion on ourselves, the years 2016 to 2021 showed cracks in the system.” —Christine Thielman





# Forward Thinking

**MIT's Mobility Initiative merges academia and the public and private sectors to help shape the future of transportation**

Few sectors of the global economy are changing as rapidly and dramatically as the mobility sector, and even fewer have mobility's broad potential to shape the way we live. New technologies are upending long-static industries such as automobile manufacturing and highway construction, and altering the way we plan our cities and homes. The climate crisis is compelling the mobility and transportation industries to innovate in ways that are not only new but also clean and sustainable.

"It's an incredibly turbulent but interesting time," says Jinhua Zhao MCP '04, SM '04, PhD '09, associate professor of transportation and city planning and founder and director of the MIT Mobility Initiative (MMI). "The transportation world is booming but in flux: the industry is being reshuffled, communities and cities are often confused and anxious about their mobility future, and the ecosystem pressure is daunting. While the major players like car manufacturers scramble to adapt, new players like autonomous vehicles and artificial intelligence (AI) stake their claim. MIT wants to play a leadership role in shaping this new reality."

**“The future of mobility isn’t being charted solely in a research university. It’s being charted in a dynamic ecosystem of big technology players, startups, entrepreneurs, academics, and civic leaders,” says John Moavenzadeh.**

Launched in 2020, the MMI provides continuity, context, and an ongoing forum for MIT researchers and key stakeholders in the mobility ecosystem, both inside and outside MIT. The Institute-spanning initiative includes 75 MIT faculty researchers from 12 departments and laboratories. Zhao has hosted a series of 62 virtual MMI Mobility Forums, showcasing the groundbreaking transportation research across the Institute and reaching over 10,000 participants and viewers from across the globe. Leaders from Hyundai Motor Group, Ferrovial, Ford, Liberty Mutual, Microsoft, US DOT, Chicago Transit Authority, and Transport for London presented during MMI’s annual Mobility Vision Day in November 2022.

“Transportation is a complex system with multiple actors in the public, private, and academic spheres,” says John Moavenzadeh, executive director of the MMI and former lead of the mobility platform at the World Economic Forum, who also developed and co-teaches the graduate-level Mobility Ventures course (see sidebar on page 20). “The future of mobility isn’t being charted solely in a research university. It’s being charted in a dynamic ecosystem of big technology players, startups, entrepreneurs, academics, and civic leaders. If we want to have a global mobility system that is safe, clean, and inclusive, we need to ground that system, to connect it across disciplines and institutions and people on the front lines. This is the type of thing that MIT can do very well.”

### **An opportunity to lead**

Jinhua Zhao came to MIT in 2013 with a joint appointment in the departments of urban studies and planning and civil and environmental engineering. In 2018, he met with a small group of MIT leaders: Provost Cynthia Barnhart SM ’86, PhD ’88; School of Engineering dean Anantha Chandrakasan; School of Architecture and Planning dean Hashim Sarkis; professor of engineering Sanjay Sarma (then the vice president of open learning); and Professor Emeritus Daniel Roos to discuss an idea for an Institute-wide project. “I observed that MIT had a long and proud history in transport scholarship,” says Zhao. “Transportation is not one single discipline but requires and unifies all sorts of expertise. And all those disciplines need to speak with each other.”

By Zhao’s design, the MMI is perched on three pillars: technology, data, and values. The first pillar supports research in subjects including energy, vehicle design and development, and aeronautics. The second encompasses

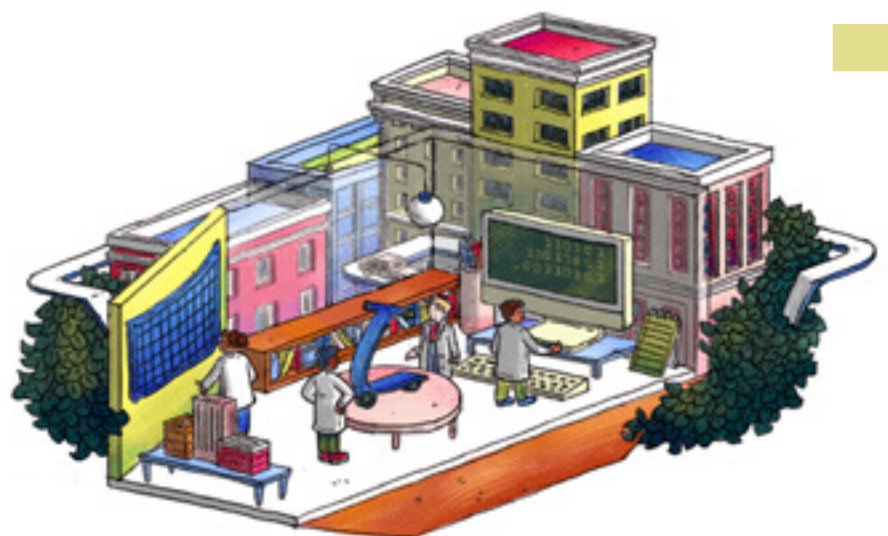
projects ranging from demand modeling to AI and big data. “The third pillar, values, is where we ask what transportation is for,” says Zhao, who also directs the JTL Urban Mobility Lab at MIT. “What purpose do our sophisticated technologies and intelligence serve? Do they alter our behaviors? Can we create a mobility ecosystem that furthers public health and creates greater equity and access? Transportation is currently the biggest contributor of CO<sub>2</sub> in the United States. Can we quickly decarbonize transportation while providing everyone the access to opportunities?”

### **Digging deep**

In March 2022, the MMI put out its first call for research proposals. “I applied with a proposal about safety and performance in autonomous vehicles,” says Cathy Wu ’12, MNG ’13, assistant professor in civil and environmental engineering. “There is a perception that the public expects autonomous vehicles to be significantly safer than human-piloted vehicles. We wanted to explore whether that should be the bar. To ask how safe is safe enough.”

To answer that question, Wu first had to ascertain how safe human drivers are. To her surprise, she discovered there weren’t sufficient data to make that calculation. Performing even a rudimentary analysis would require simulating billions if not trillions of miles of driving, a largely futile operation requiring enormous resources. Instead, Wu is using neural surrogate modeling, a machine-learning technique, to simulate and analyze specific driving and traffic scenarios. “That would establish a baseline,” Wu explains. “Then regulators could debate whether autonomous vehicles should be 5 or 10 or 25 percent safer. And whether that level should change over time.”

Andres Sevtsuk SM ’06, PhD ’10, the Charles and Ann Spaulding Career Development Professor of Urban Science and Planning, is also undertaking research projects with MMI. “We want to know whether we can have built environments that don’t require everyone to drive,” says Sevtsuk, who explores public transport, cycling,



and walkability. “With the demographic shifts we’re seeing, away from suburbs and into cities, can we see something other than cars 2.0 emerge? New transport services, personal mobility devices like scooters, and the challenge of charging the growing electric fleet have thrown the field into a whirlwind. The MMI is helping to create clarity and also linking the private sector with city, state, and federal governments.”

#### Asking the big questions

Karl Iagnemma SM '97, PhD '01, CEO of the Boston-based company Motional, which develops autonomous vehicle technology for major ride-hail companies including Lyft and Uber Eats, says the MMI offers both an invaluable network and a fresh perspective for its industry partners. “In industry, we are too often tied up in shorter-term technologies and strategies,” says Iagnemma, who recently joined MMI’s Global Advisory Board. “MIT is looking at fundamental questions related to the future of transport and mobility. They ask the ‘what ifs’ that could lead to meaningful strategies across the sector, in business, autonomous transport, urban planning, and policy.”

In addition to providing a holistic platform

to view mobility, the MMI is also training personnel to drive the sector towards greater efficiency, sustainability, and change. “The Mobility Initiative provides great value as a place where the brightest minds from private, public, and academic organizations can connect,” says Regina Clewlow PhD '12, CEO and cofounder of Populus, a data platform that helps private mobility operators and cities deliver safe streets for all forms of transit. “But it will also produce graduates with expertise in transport and mobility to work in those organizations.”

Wu says the MMI is already playing a vital role in shaping transportation—and society. She also believes the initiative can serve as a test bench, a first-generation experiment in facing and resolving a complex global problem. “Transportation, in the end, feels like one of our more tractable systems,” says Wu, who studied electrical engineering and computer science as an MIT undergraduate. “We don’t really understand why people click on a specific social media link, or why they choose to take their medication or not. We do understand how and why people hit the brake pedal. And we have decades of modeling under our belt. If we do this right, we can create the methods and tools that can help resolve far messier global problems.”

—Ken Shulman



## Mobility Ventures: Making Transportation Your Business

“We emphasize the idea of mobility as a system,” says John Moavenzadeh about the Mobility Ventures course he co-teaches with the Martin Trust Center for MIT Entrepreneurship managing director Bill Aulet SM '94, who is also the Ethernet Inventors Professor of the Practice of Entrepreneurship; Jinhua Zhao MCP '04, SM '04, PhD '09; and Jenny Larios Berlin MCP/MBA '15, entrepreneur in residence at the Martin Trust Center. “We want our students to understand that the many different stakeholders within the mobility system—regulators, startups, big corporates—have different and often competing incentives. They need to understand these incentives to change the broader system.”

Mobility Ventures has been offered jointly by the MIT Sloan School of Management and the

Department of Urban Studies and Planning to students from MIT, Harvard, Tufts, and Wellesley since 2020. In one class exercise, students organize into small teams to explore a mobility problem and then present a proposed solution to their peers. “The exercise teaches them to see the broader picture,” says Moavenzadeh, executive director of the MIT Mobility Initiative (MMI). “It’s not just designing a better scooter and dumping them in the middle of a city. You need to involve the city officials to plan how they will be used and where they will be charged and stored.”

“This class brings the perspectives of behavioral thinking and computational thinking together to identify venture opportunities,” says Zhao, director of the MMI. Mobility Ventures has featured fireside chats and intensive Q&A

sessions with a bustling roster of industry heavyweights including Kyle Vogt '08, CEO and cofounder of the GM-owned self-driving company Cruise, and Mark Rosekind, a former official with the National Highway Safety Administration.

“The highlight was the visit from Dean Kamen, inventor of the Segway,” says Sloan Fellow Morgan McCray MBA '23, who came to MIT after a decade of work in the public and private sectors. “I sought out this class to understand what is going on in the mobility industry, to better understand the opportunities for integration that exist between the many stakeholders, and to learn how we can incentivize people and institutions toward change. This course is a beautiful hybrid that bridges all those elements.”

—Ken Shulman

# The Dynamism of Human Patterns

**Civic Data Design Lab visualizes data on the movements of people—and moves audiences in the process**

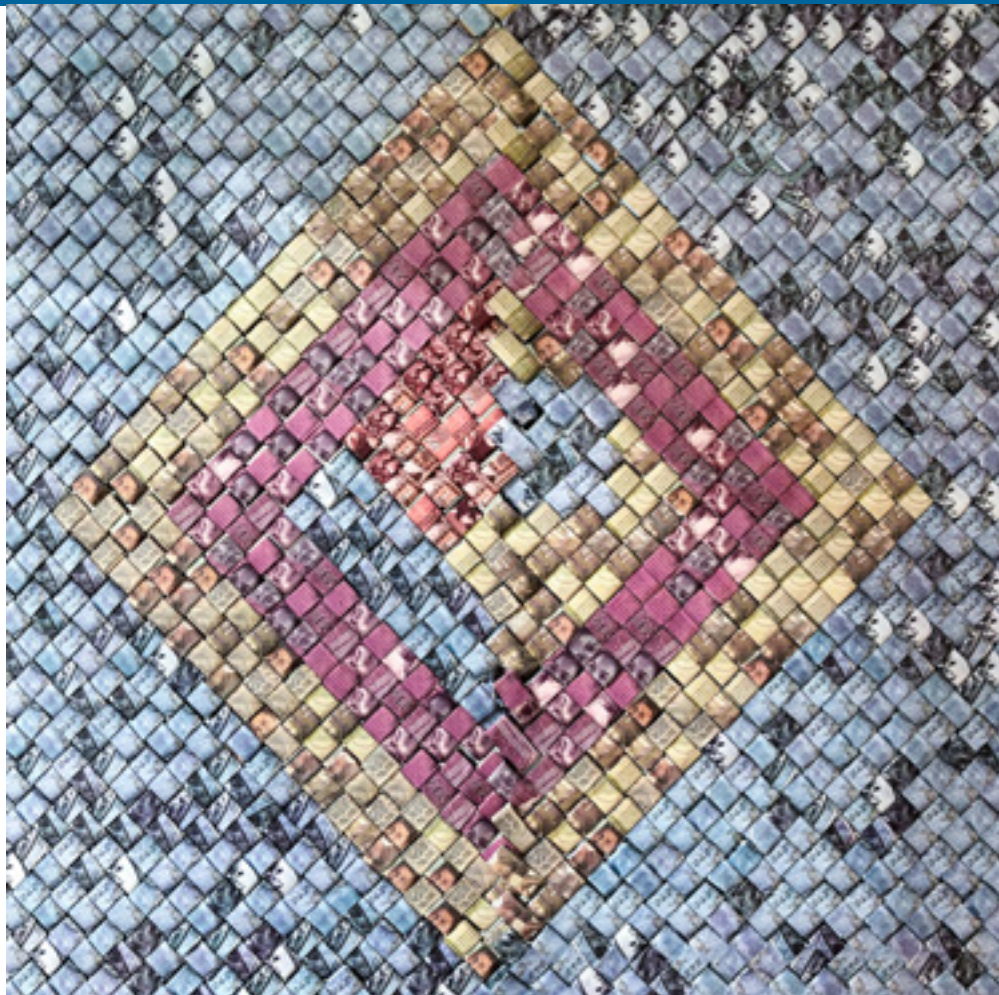
“I think any city planner would say that movement is essential to the work that they do—transportation, the movement of people through the city, but also the change of movement of people over time, and how cities can change to address that,” says Sarah Williams MCP ’05, the Norman B. and Muriel Leventhal Professor in the MIT Department of Urban Studies and Planning and director of the Civic Data Design Lab (CDDL), which works to understand data for public good through creative visualizations and reports.

“We live in dynamic, moving places, and the data are always moving, too,” she says. “It’s important to make sure the algorithms and predictive models that we make account for the dynamism of human patterns.”

People move across the globe for a number of reasons. In 2021, the CDDL co-authored *Charting a New Regional Course of Action: The Complex Motivations and Costs of Central American Migration*, a comprehensive report about patterns in migration from Central America. The CDDL interviewed nearly 5,000 households for the project, which also spurred an interactive online report and a multifaceted artistic exhibition called *DISTANCE UNKNOWN* that premiered at the 2022 United Nations World Food Programme executive board meeting in Rome. The exhibition received a Responsible Disrupter Award from *Metropolis Magazine* and will appear at the 2023 Venice Biennale.

A striking component of *DISTANCE UNKNOWN* is *Motivational Tapestry*, a 15-by-8-foot installation woven from 5,000 bills of currency representing the migrants interviewed for the report—a significant percentage of whom cited economic distress as their reason for migrating to the United States. Viewers are encouraged to take a piece of the tapestry and scan it at a touch-screen station, where the story of that migrant appears.

“We can forget that those points on a chart or map represent people who have hopes and dreams who, in this case, don’t have the money they need to live. Remembering that can connect you to the human situation more deeply,” says Williams. “But a point on a graph on the chart is also very effective to another group of people. So we do the traditional reports as well as the visualizations because we know that different ways of taking in information are important.”



An installation woven from bills of currency, *Motivational Tapestry* represents the 5,000 migrant households interviewed for the Civic Data Design Lab’s 2021 report on migration patterns.

PHOTO: COURTESY CIVIC DATA DESIGN LAB

## Data and design to tell important stories

That marriage of data and artistic design is central to the CDDL’s mission. The lab is taking on more migration-centric projects in other parts of the world, including West Africa and Venezuela. “We will likely see large populations moving into cities as agricultural land becomes unusable due to issues of climate change in some of these regions,” Williams says. “Migrants are typically seeking a better economic lifestyle, but often their economic losses are due to climate change as well as violence and insecurity within the region in which

they live. Our goal is not necessarily only to encourage migration but to identify the problems that lead to it so they can be addressed.”

The data gathered for the project, which includes responses to more than 100 questions on topics beyond economics, feature prominently in a new Common Ground course offering from the MIT Schwarzman College of Computing. Williams co-teaches the course, *Interactive Data Visualization and Society*, with Arvind Satyanarayan, associate professor of computer science, and Catherine D’Ignazio SM ’14, the Sherman Fairchild Career Development Professor and associate professor of urban studies and planning. “This approach is a great example of how to bring data and design together to tell important stories about society,” Williams says.

The timing was right to bring about dramatic results: in November 2021, 33 senators made recommendations to the White House to create more legal pathways for Central American migrants, citing the CDDL’s study. In June 2022, the Biden administration did just that.

The in-person element of *DISTANCE UNKNOWN* at the World Food Programme was a striking aspect of the project; Williams recalls powerful reactions from ambassadors at the Rome exhibition, leading to more thoughtful, empathetic, and productive discussions among them.

“When someone receives a policy report or academic paper, it can be easy to push it aside,” says Williams. “Viewing the exhibition in person can allow people to open their eyes to a problem from another vantage point.” —Joelle Carson

# A Robotic Helping Hand

Mechanical assistants could help preserve independence for people as they age

Harry Asada smiles warmly when he recalls his mom, Yoshiko Asada, who lived in Osaka, Japan. She spent much of her time volunteering and “was a very independent old lady,” he says. But after breaking a hip in a fall at age 89, she developed complications and then dementia. “She became a different person after that,” Asada says, remembering the chain of events that motivated him to move his mother into a nursing home. Over the next 15 years, her functions slowly declined, and she became a wheelchair user. She passed away in early 2022 at age 104. “Amazing,” Asada chuckles.

This loss of autonomy is a common trajectory for people as they age. Asada says that most older adults don’t want to go to a nursing home. “They want to live more independently,” he explains. “And it’s not a good thing for them to be disconnected from their familiar community.” Not to mention the price tag, says Asada, combined with a growing elderly population worldwide and a shrinking workforce to support them.

Graduate student Roberto Bolli ’20 demonstrates a robot designed to provide a grab bar that can move in response to a patient’s needs.

IMAGES: COURTESY OF ROBERTO BOLLI

Asada, the Ford Professor of Engineering in the Department of Mechanical Engineering, says robotics may be able to help elderly people retain their independence and live at home for longer, a concept often referred to as aging in place. He admits that it’s difficult for someone to regain the mobility that they’ve lost. Instead, Asada, who is also director of the Brit and Alex d’Arbeloff Laboratory for Information Systems and Technology, is focusing his efforts on slowing physical decline, preventing falls, and improving overall balance.

## A human must be in the loop

Take the task of standing up from a sitting or reclining position. An elderly person might have grab bars installed on the walls of their home “but the ideal bar locations are not necessarily the walls,” says Asada. It would be more helpful to have bars that can float in mid-air, in front of or beside the person. One of Asada’s graduate students and a Flowers Family Graduate Fellow, Roberto Bolli ’20, outfitted a collaborative robot arm with a handlebar and attached it to a mobile base called Handle Anywhere. It can be teleoperated by a health professional or run autonomously.

“A human must be in the loop,” cautions Asada. “If the robot were to approach the

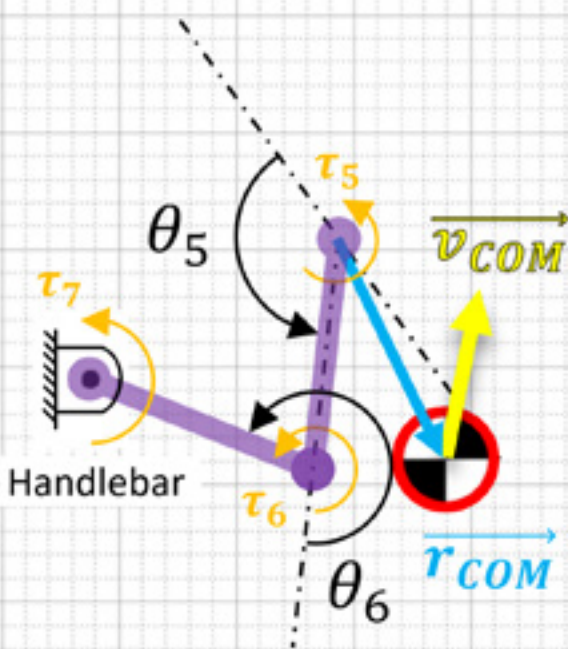
person and yank their arms to stand up on their feet, that would be rather terrifying. Instead, the robot needs to communicate with the user to ascertain their willingness to stand up, and develop a cooperative, trusting relationship.” This is accomplished by having the elderly person lean forward before the robot starts to lift their body. Because today’s robotics are not yet at that level, the current setup requires human supervision. Ideally, the machine would behave like a well-trained and compassionate caregiver who offers both physical and sympathetic support.

## Exercise safety net

Another of Asada’s efforts focuses on tai chi. His collaborator Peter Wayne, associate professor of medicine at Harvard Medical School and associate epidemiologist at Boston’s Brigham and Women’s Hospital, says the Chinese martial art can enhance mobility, balance, and mental health. Asada and Wayne have found that medical professionals often discourage the elderly and frail from practicing tai chi because of the risk of falling.

In response, Asada and Wayne are developing a tai chi robotic assistant. A metal frame supports a spray of cables and winches that attaches to a special pair of pants built by a student in his lab, Emily Kamienski SM ’21, and a visiting scholar, Hirofumi Itagaki. “When the person doesn’t need assistance, the robot is almost invisible,” explains Asada. But when sensors in the pants detect that the individual is losing their balance, the winches engage, the cables tighten, and the pants grip the person mid-fall, supporting up to a quarter of their body weight. “With this kind of safety net,” Asada says, “the people who really benefit from this exercise can do it safely.” In addition, it’s a way of continuously monitoring someone’s balance and risk of falling.

Neither robot is on the market yet, says Asada, who notes that this is delicate and difficult work. But the payoff of success would be enormous, providing people with robotic assistance to remain healthy, independent, and meaningfully engaged with their communities and loved ones. Asada likes to think his mom would be proud. —Ari Daniel PhD ’08





# Oceans of Data

**Bianca Champenois SM '22 helps model the future for coastal industries**

Bianca Champenois SM '22 looks at a digital map of Massachusetts Bay speckled with dozens of maroon, blue, gray, purple, and orange dots.

The dots represent continually shifting temperatures at the surface and at various depths, as measured by satellites and sensors mounted on buoys, clipped to lobster pots, and dangled from boats. In an innovative new project, Champenois, a PhD candidate in mechanical engineering, uses these data points to model conditions affecting acidity, a growing problem for the bay, according to the 2021 Report on the Ocean Acidification Crisis in Massachusetts.

Recreational and commercial saltwater fishing, shell fishing, and whale watching along the 60 miles of coastal waters are vital to the Massachusetts economy. Last year's report from the state's Special Legislative Commission on Ocean Acidification notes that these multimillion-dollar industries are adversely affected by changing ocean chemistry tied to human activities.

Working with the MIT Sea Grant College Program, which applies MIT research and engineering to ocean-related challenges, Champenois is developing a real-time monitoring system to track ocean acidification from the bay's northernmost edge at Cape Ann down through Boston Harbor and ending at the vast flexed elbow of the outer Cape Cod.

With Themis Sapsis PhD '11, professor of mechanical and ocean engineering, Champenois works on new frameworks for modeling geophysical systems of land, air, and water. "My goal is to intelligently use available data and provide more informed estimates of uncertainty," she says.

"Satellite measurements can give you temperature data, but that's only at the surface," Champenois says. "We use a combination of physics and physics-based numerical simulations, along with new machine-learning techniques and data obtained from comprehensive ocean models, to predict the 3-D temperature field of the bay over depth and time."

The models, she says, will lead to a "better-informed understanding of ocean acidification." Measuring temperature at different depths is key because warm water tends to acidify faster.

According to the US Environmental Protection Agency, ocean acidity has risen around 25% since preindustrial times. The increasing amount of atmospheric carbon dioxide dissolved in the water forms carbonic acid, making seawater more acidic and negatively impacting marine life such as scallops and oysters, which use carbonate from the water to build shells.



As seawater becomes more acidic, carbonate is less available. In addition, freshwater runoff from cities, factories, and farms "changes the ocean's ability to maintain its own optimal pH, so it actually worsens the effects of ocean acidification," Champenois says.

Champenois aims to predict properties of the water at all locations and depths, not just at the surface. Satellite data are useful but problematic: "If it's cloudy, you can't get any data. So, in the winter, your data are a lot worse," she says. "And even in the summer, some patches of the ocean will have fewer data."

A web-based visualization tool called Sea Glass will make Champenois's results available to stakeholders such as research scientists, industry analysts, and the US Coast Guard. "High school students, or anyone who's interested, can also have access," she says.

Champenois grew up in California, spending summers at her grandfather's home on the West Coast of France, where the main industry is collecting sea salt for the gourmet market at high tide. "My family is definitely an ocean family," she says.

As an undergraduate at the University of California at Berkeley, she worked on environmental fluid mechanics. When Covid-19 hit, she delayed her move to Boston to start the MIT graduate program. Instead, she headed to Santa Barbara, took classes virtually, and learned how to surf. "It was really fun to learn about the hydrodynamic period of the waves and then go surfing and see it for myself," she laughs. Now, she's excited to expand her knowledge and skills to encompass the East Coast.

As global needs for food increase, coastal industries may need to move their operations further offshore. There is little data on how fish farms, for instance, will function in these different flow and temperature conditions, and how to best monitor them.

Champenois hopes to extend the techniques she's developing to measure dissolved oxygen and carbon, allowing stakeholders to assess and predict conditions for new initiatives far into the open ocean, pushing ahead into uncharted waters. —Deborah Halber

# Movin' on Up

**An ongoing study by MIT Sloan professor Nathan Wilmers examines how changing job tasks can lock in higher wages over time**

For decades in the United States, the income gap has been widening, increasing class divides and constraining economic mobility. MIT Sloan School of Management associate professor Nathan Wilmers was surprised, then, to find in a new analysis of data that the gap has actually narrowed in the most recent decade, with the lower third of workers seeing faster wage growth for the first time since the 1970s.

“It’s been a period in which workers have had some increased bargaining power and have been able to make some real gains,” says Wilmers, the Sarofim Family Career Development Associate Professor of work and organizations, attributing the decline in part to a tightened labor market in the wake of the Great Recession and Covid-19 pandemic. “The big question, however, is whether that change is going to be durable.”

Without fundamental shifts in how employers organize their businesses, he says, all it would take is a rise in unemployment to see that gap widen once again. To help prevent that from happening, Wilmers is conducting an ambitious new study along with Harvard Business School assistant professor Letian Zhang to examine how the type of work that low-wage workers do might affect their long-term wage growth and economic mobility.

The study is funded by a grant, one of nine totaling \$2.1 million, from WorkRise, described as a research-to-action network hosted by Washington, DC-based think tank the Urban Institute. Wilmers and Zhang’s study was chosen from the 343 grant applications for research on jobs,

Factory workers are likely to enjoy higher wage growth and greater job security when given more complex tasks.

PHOTO: JAKE NEBOV  
ON UNSPLASH

workers, and mobility. Wilmers and Zhang hypothesize that frontline workers are apt to see higher wage growth when their positions include a wide variety of tasks, including some that are more complex, rather than a small number of basic duties.

“If you organize work so that people are doing the same simple, repetitive thing day after day, they are less likely to be learning and developing human capital than if you have a job rotation where people move across multiple tasks within a workplace,” Wilmers says. That higher-order training can lead to more advanced positions in the future. In addition, he says, job variety can translate to higher wages in the current workplace by making a worker more valuable to a company and increasing their bargaining power to negotiate pay raises.

This reorganization of work could look different in various settings. At a call center, for example, it might mean that instead of being required to follow a script with little discretion to deviate, a worker would have the autonomy to address more complex customer problems. In a retail environment, it could mean that instead of working exclusively as a cashier, an employee can check on stock issues and set up product displays. In a medical center, an administrative assistant might not just check in patients, but also coordinate care between multiple providers. “That requires a lot more know-how,” says Wilmers, “but can be a really effective way to expand the job, increasing learning opportunities while at the same time filling a big hole we have in the medical system.”

### Insights from wage data, job descriptions

To test their hunch that more complex tasks lead to higher wage potential, Wilmers and Zhang are using a restricted data set from the US Census Bureau drawn from employers’ quarterly earnings data from 2010 to 2015. In addition to tracking wage data over time, the researchers are scraping job sites to identify the range of tasks included in different postings. By combining wage data with job descriptions, they can see directly how a mix of tasks affects long-term economic mobility. They hope to add data from 2015 to 2020 soon, thereby showing trends across a full decade.

Wilmers says the data so far seem to bear out their assumptions that more involved tasks lead to positive wage growth. By drilling down into exactly what job assignments contribute to such growth, Wilmers hopes the study can give workers keener insight about how to maximize earning potential over time.

That doesn’t mean employers will lose out, however. “This isn’t about just getting employers to be altruistic,” he says. By training workers in higher-order duties, Wilmers says, “employers might also benefit by attracting and retaining workers in these frontline positions and potentially increasing productivity and efficiency as well.”

In this way, everyone might reap rewards from the decreasing wage gap of the past decade and continue that momentum in the future. Ultimately, Wilmers adds, distributing economic gains more equitably is better for society. “It’s really exciting that we have an opportunity right now where some of these negative trends are starting to reverse,” he says. “As a researcher, I am interested in identifying ways that employers, workers, unions, and policy makers can all contribute to locking that in and figuring out a way to get us back to more egalitarian economic growth.” —Michael Blanding

## Startup Helps Immigrants Build Financial Future

For the more than 100,000 people from the African continent who move to the United States every year, opening a local bank account or figuring out how to cheaply send money back home can be fraught with obstacles. The creators of a new app called CashEx want to help do away with such barriers to financial mobility, offering these immigrants a better way to safeguard and access their resources.

Devised by Scott Morgan, an MBA student at the MIT Sloan School of Management, and Kingsley Ezeani, who earned an MBA at Oxford and an MPA from the Harvard Kennedy School, CashEx was among the startups in the 2022 cohort of MIT’s student venture accelerator program delta v. It also won the grand prize in Harvard Business School’s New Venture Competition.

The digital service is designed to help African migrants obtain their first US bank account and debit card just before their arrival in the United States and to help facilitate the transfer of their savings. It also plans to offer zero-fee remittances for sending money back to their countries of origin.

“We know that moving across the globe to build a life in a new country is incredibly stressful, and we want to ensure that interactions with financial services will not add to that stress,” says Morgan, CashEx’s chief technology officer, who says his previous experience in financial services exposed him to the challenges of moving money internationally.

Ezeani, the startup’s CEO, has also experienced those challenges, although on a more personal level. When he set out from Nigeria to travel to the United States for the first time to pursue his degree at the Harvard Kennedy School, he says he was worried about being robbed along the way.

“We want to create a future where immigrants are able to get the same access to financial services as the rest of the population in the United States,” he says of CashEx. “One where we have eliminated the high remittance fees immigrants pay to send money to their families.”

CashEx has received funding from Google’s Black Founders Fund and recently launched on Google Play and the Apple App Store, where it drew 50,000 wait-list sign-ups in two months, Ezeani notes.

Morgan credits the Martin Trust Center for MIT Entrepreneurship’s delta v program for helping the cofounders shape a promising startup. “Five or 10 years down the road, we hope that our venture will be the bank of choice for migrants around the world,” he says.

—Mark Sullivan

# Grains of Innovation

## Newly endowed, MIT Sandbox ensures enterprising ideas can take shape

Since the MIT Sandbox Innovation Fund Program was created in 2016 by the School of Engineering, it has provided funding in the \$1K to \$25K range to hundreds of undergraduate and graduate student entrepreneur teams to develop and launch their businesses. In 2022, the program received a \$1 million gift from Daniel Gilbert '91 and his wife, Judy, providing a permanent source of funding with the establishment of the MIT Sandbox Endowment Fund and ensuring that students' creative technologies, ideas, and business concepts will have a supportive home for years to come.

Many MIT Sandbox spinouts seek to take on big challenges, such as health care and sustainability. *Spectrum* spoke to two recent alumni whose companies are making a splash.

### Using AI to revolutionize the fight against heart failure

**Claire Beskin MBA '22 and Ruizhi "Ray" Liao SM '17, PhD '21**

Claire Beskin always had an interest in health care and occasionally even shadowed her physician father while he worked. But it was pure coincidence that the first MIT hackathon she attended focused on the subject. It inspired her to pursue a health care-related business idea, and after meeting cofounder Ray Liao, then a computer science PhD candidate, she joined his MIT Sandbox team. Their collaboration resulted in the formation of Empallo, a software company that builds algorithms to assess health records for patients with heart failure and other cardiovascular syndromes and diseases.

Heart failure is responsible for about 1 million hospitalizations each year in the United States and \$12 billion in hospitalization costs. Twenty percent of heart failure patients are readmitted to the hospital within 30 days of discharge. "This results in huge costs to hospitals and danger to the patient," Beskin says. "We're collaborating with several hospitals across the US to enhance and test our algorithms to improve heart failure management." The future may bring partnerships with pharmaceutical and medical device companies, too, as the software is poised to support both clinical trial design and clinical practice.

MIT Sandbox funding has been essential in helping Empallo get off the ground, Beskin says. "I don't think we would still exist if it weren't for MIT Sandbox. In our first year, it was really helpful to have that support for a variety of expenses, from early consumer discovery activities to office supplies to legal advice about company formation and patent filing," she says. "MIT is setting the pace for universities to listen to startup founders, hear what they need, and create programs and resources to support them, which helps explain why so many companies come out of MIT."

### Turning aluminum recycling waste into green energy

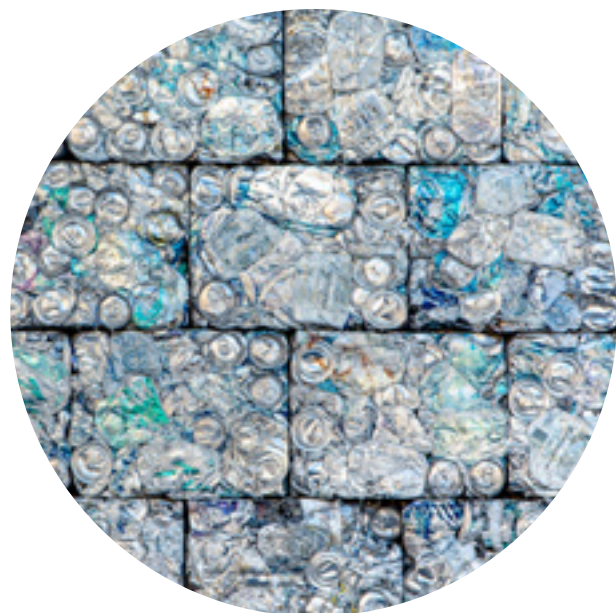
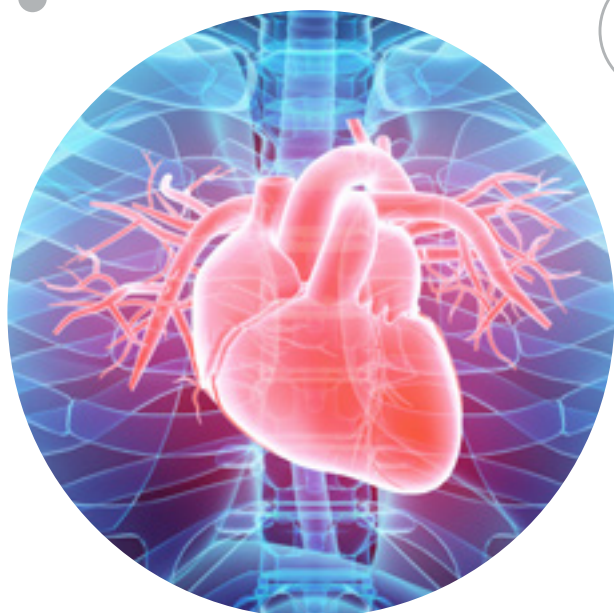
**Rostam Reifschneider '21**

"Growing up between never-ending droughts and wildfires in California made me want to pursue a career fighting climate change," says Rostam Reifschneider. "I decided to study mechanical engineering at MIT and use a combination of STEM and entrepreneurship to build a company that would make a big impact." When the Covid-19 pandemic made it necessary for Reifschneider to return to California to do his senior year remotely, he reconnected with a high school friend, Julian Davis, who was completing his degree in physics and management at Georgetown University and shares a similar passion for climate action. The two ended up founding Hydrova, a company that uses zero-waste technology to recover valuable aluminum, salt, and oxide products from dross and salt cake while generating hydrogen for clean energy use in recycling plants.

MIT Sandbox was instrumental to Hydrova's earliest stages, says Reifschneider. "In September 2020, while we didn't have access to any campus resources, we'd been self-funding experiments in my garage," he says. "In addition to the Sandbox funding helping us to prove out the technology, our first meeting with the Sandbox Funding Board pointed us in the right direction and helped us focus on developing a solution with a commercial potential."

Hydrova hasn't stopped since: in 2022, the company began a large-scale pilot trial with California's largest aluminum recycling plant diverting 5,000 pounds of aluminum waste to Hydrova's new zero-waste facility.

Reifschneider encourages MIT students to get involved with the "amazing" programs at MIT and make the most of the experience but also to nurture relationships. "Focus on your personal life and making friends as well as the academic part," he says. "You may even end up being cofounders or business partners in the future." —Joelle Carson





Recent gifts to the School of Architecture and Planning are helping to ensure the school remains a leader in education, research, and innovative practice.

PHOTO: GRETCHEN ERTL

# Two Stories of Philanthropy

**Gifts bolster architecture department in distinctive ways**

Two significant gifts to the MIT School of Architecture and Planning (SA+P) offer different but equally transformative examples of philanthropic leadership in action. In December 2021, Alan G. Spoon '73, chair of the Department of Architecture Visiting Committee, and his wife, architect Terri Spoon, established the Terri and Alan Spoon Professor of Architecture and Climate—the second full professorship in the department since 1978—and the Spoon Climate Studio. In September 2022, Berkeley Investments, founded by visiting committee member Young K. Park '71, contributed discretionary funds to strengthen and enrich the student experience in architecture.

Both gifts are enabling the architecture department and SA+P to remain at the leading edge of education, research, and innovative practice while navigating a challenging financial climate.

## **Prioritizing climate-related research in architecture**

“The climate crisis requires many important shifts in building and construction,” says professor and architecture department head Nicholas de Monchaux. “As the home of the first professional architecture program in North America, and the home of pathbreaking research in building today, MIT is well positioned to be a leader in addressing this existential challenge.” Yet funding for this work lags far behind the need, he notes, making gifts like the Spoons’ particularly crucial.

Christoph Reinhart, professor and director of the

Building Technology Program and the Sustainable Design Lab, has been named the inaugural Terri and Alan Spoon Professor of Architecture and Climate.

Caitlin Mueller '07, PhD '14, SM '14, associate professor of building technology, and Sheila Kennedy, professor of the practice in architecture, were chosen as co-leaders of the inaugural Spoon Climate Studio and will lead a series of workshops and studies beginning in 2024 that will offer a critical cultural inquiry into the modern development of standardized building construction materials.

“The Spoons’ gift will be a catalyst in seeding important climate-related research in the Department of Architecture that could not happen otherwise,” says de Monchaux. “It reflects Alan’s sense of service to MIT and the keen interest that Alan and Terri have for unlocking our department’s potential to face the largest contemporary challenges.”

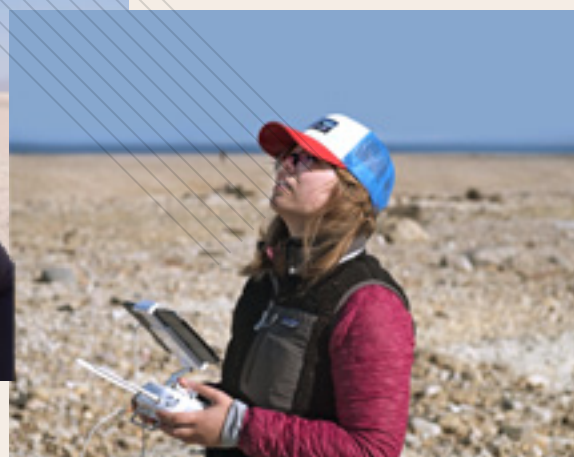
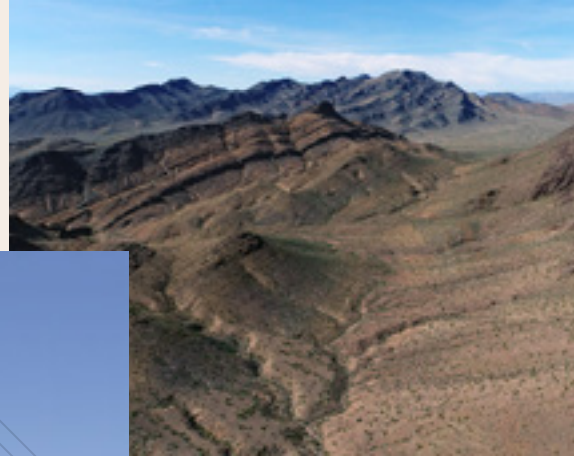
## **“A gift of care” to ensure an excellent student experience**

At a meeting of the Architecture Visiting Committee in April 2022, de Monchaux spoke about the robust student experience the department aims to provide as well as the challenges it faces in meeting that aspiration, including the rising cost of living and inflation and supporting an increasingly economically diverse student body. Committee member Park, an SA+P alumnus, was inspired to help.

“Members of the visiting committee are able to get an unvarnished glimpse at the inner workings of SA+P departments,” says Park. “Amid the transformative achievements of the past year, we were also made aware of continuing resource gaps, including the ever-increasing expenses borne by graduate students and PhD candidates. Berkeley Investments’ multiyear funding commitment is designed to address this gap, and we hope it will be a useful complement to traditional capital funding.”

The gift will be used to avoid charging specific fees to students for travel, printing, and modeling and prototyping in their studies. “It will expand student access and empower them to use our facilities and workshops. This is incredibly important during a time of budgetary challenges. For students, it’s a gift of care that will enhance their experience.”

Though the designations of these two gifts are quite different, de Monchaux sees an important link between them. “What these gifts share is a spirit of curiosity and generous listening. Both gifts are connected to individuals who have given significant time and service to MIT over the years” and who appreciate the importance of addressing the climate crisis in the built environment and supporting an ever-more-diverse student population. “These are remarkable gifts of confidence in our work and priorities.” —Kris Willcox



# The Freedom to Explore

Alumni say Whiteman Fellowship gave them room to break ground as scientists

A paleomagnetist who studies the magnetic properties of ancient meteorites for insights into the genesis of our solar system, Clara Maurel PhD '21 credits the Whiteman Fellowship she held as a graduate student at MIT with helping shape the direction of her research.

“The reason I had so much freedom to explore the questions I thought were the most interesting early in my PhD is because I had the fellowship,” says Maurel, a Whiteman Fellow in the Department of Earth, Atmospheric and Planetary Sciences (EAPS) in 2017–2018.

Today, Maurel is a postdoctoral researcher at the European Center for Research and Education in Environmental Geosciences in Aix-en-Provence, France.

“Currently, I am working on a very old meteorite that may preserve the record of the earliest magnetic field that existed in the solar system,” she says. “What excites me most is working with amazing objects that existed 4.5 billion years ago, before the planets were formed, which I can take in my hands to study.”

## “A very important bridge at a critical time”

Maurel is echoed by other Whiteman alumni who say the graduate fellowship’s crucial support helped plot the trajectory of their careers.

“The Whiteman Fellowship gave me a very important bridge at a critical time,” says Marjorie Cantine PhD '21, who held the fellowship in EAPS in 2016–2017 and is now a postdoc at the Frankfurt Isotope and Element Research Center at Goethe University Frankfurt in Germany. There, she says, her work laser-dating carbonate rocks formed 500 million years ago “has the potential to help us understand the history of life and our planet in more detail than ever before.”

The Whiteman Graduate Fellowships in Astrophysics and in EAPS at MIT were created by George Elbaum '59, SM '63, PhD '67 and his wife, Mimi Jensen, and named for Elbaum’s mother, Pauline Whiteman, who saved her son’s life by smuggling him out of the Warsaw Ghetto as a child during the Holocaust.

Now in its 20th year, the Whiteman Fellowship in Astrophysics has been awarded 92 times to graduate students. The Whiteman Fellowship in EAPS, established in 2013, has been awarded 17 times.

“The Whiteman Fellowship gave me the freedom to take the leap and go for the project that really excited me in graduate school,” says Sarah Trowbridge Heine '08, PhD '14, an astrophysics fellow in 2008–2009. “I worked on Micro-X, a sounding rocket payload carrying an array of microcalorimeters, which measure the energy of incoming light very precisely. It was an extremely challenging instrumentation project. After my first year working on Micro-X, I knew it was the path for me.”

Now a research scientist with the MIT Kavli Institute for Astrophysics and Space Research, Heine helps develop technology for X-ray astrophysics. One of her projects is a NASA-funded sounding rocket payload called REDSoX (Rocket Experiment

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Far left: Clara Maurel PhD '21, a postdoc at the European Center for Research and Education in Environmental Geosciences in Aix-en-Provence, France, is working on a meteorite that may preserve the record of the earliest magnetic field in the solar system.

PHOTO: COURTESY OF CLARA MAUREL

Left: Marjorie Cantine PhD '21 is a postdoc at the Frankfurt Isotope and Element Research Center at Goethe University Frankfurt in Germany, where she laser dates ancient carbonite rocks.

PHOTO: COURTESY OF MARJORIE CANTINE

Demonstration of a Soft X-ray Polarimeter) that will measure the polarization of X-rays from astrophysical sources such as neutron stars and black holes as a function of energy, she explains.

“Scientifically, every time we build a better detector, we learn something new and unexpected,” she says. “Astrophysical systems are some of the most extreme places in the universe and offer the opportunity to study both the systems themselves and the underlying basic physics driving those systems that can’t be replicated experimentally on Earth.”

#### **Supporting a transition, encouraging exploration**

Margaret Duffy PhD '21, the Whiteman Fellow in EAPS in 2016–2017, says she started graduate school at MIT in oceanography but through her coursework realized she wanted to focus her research on the atmosphere. “This meant making a pretty big transition, including switching projects and advisors,” Duffy says. “The Whiteman Fellowship funded me during that transition and allowed me to become an atmospheric dynamicist, which I am now.”

A postdoc at the National Center for Atmospheric Research in Boulder, Colorado, Duffy describes her investigations into climate change and the dynamics of the atmosphere as “both exciting and scary.” Her current research into what is called cloud feedback aims for a better understanding of how the Earth’s climate responds to manmade emissions, with the hope of constraining warming seen accompanying an increase of carbon dioxide in the atmosphere.

“The Whiteman Fellowship gave me the opportunity during my first year at MIT to carefully consider the type of research I wanted to pursue,” says Barak Schmookler PhD '18, who held the fellowship in particle physics in 2012. His research into the underlying structure of protons and neutrons aims to “deepen our understanding of how the fundamental particles and forces create the visible matter that we interact with in our daily lives,” says the assistant project scientist at University of California, Riverside.

“In my current position, I work with many students, both graduate and undergraduate,” Schmookler says. “My time at MIT taught me that students need both guidance on their research as well as the freedom to pursue the work that most interests them.” —Mark Sullivan

“I benefited from a three-year fellowship to pursue doctoral studies at MIT, which allowed me the invaluable freedom to select research and a dissertation topic without any outside funding. I wanted to offer this same freedom to others—thus, the Whiteman Fellowships.”



George Elbaum '59, SM '63, PhD '67, who with his wife, Mimi Jensen, created the fellowships named in his mother's honor in astrophysics and in EAPS at MIT. Elbaum earned four degrees from MIT: a bachelor's in 1959 and a master's in 1963, both in aeronautics and astronautics, and a master's in 1963 and a PhD in 1967, both in nuclear engineering. In 2023, the Whiteman Fellowship in Astrophysics celebrates two decades of supporting MIT graduate students.

PHOTO: COURTESY OF GEORGE ELBAUM AND MIMI JENSEN

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## DEEP IMPACT

Members of the MIT Swimming and Diving Team, the Engineers, compete during a Senior Day meet at the Zesiger Center pool in January 2023. After students in the Class of 2023 were honored, both the men's and women's teams defeated Amherst College. The Zesiger Center, which marked its 20th anniversary in 2022, offers state-of-the-art fitness programs available to the entire MIT community.

PHOTO: SARAH BASTILLE PHOTOGRAPHY



FOR A BETTER WORLD