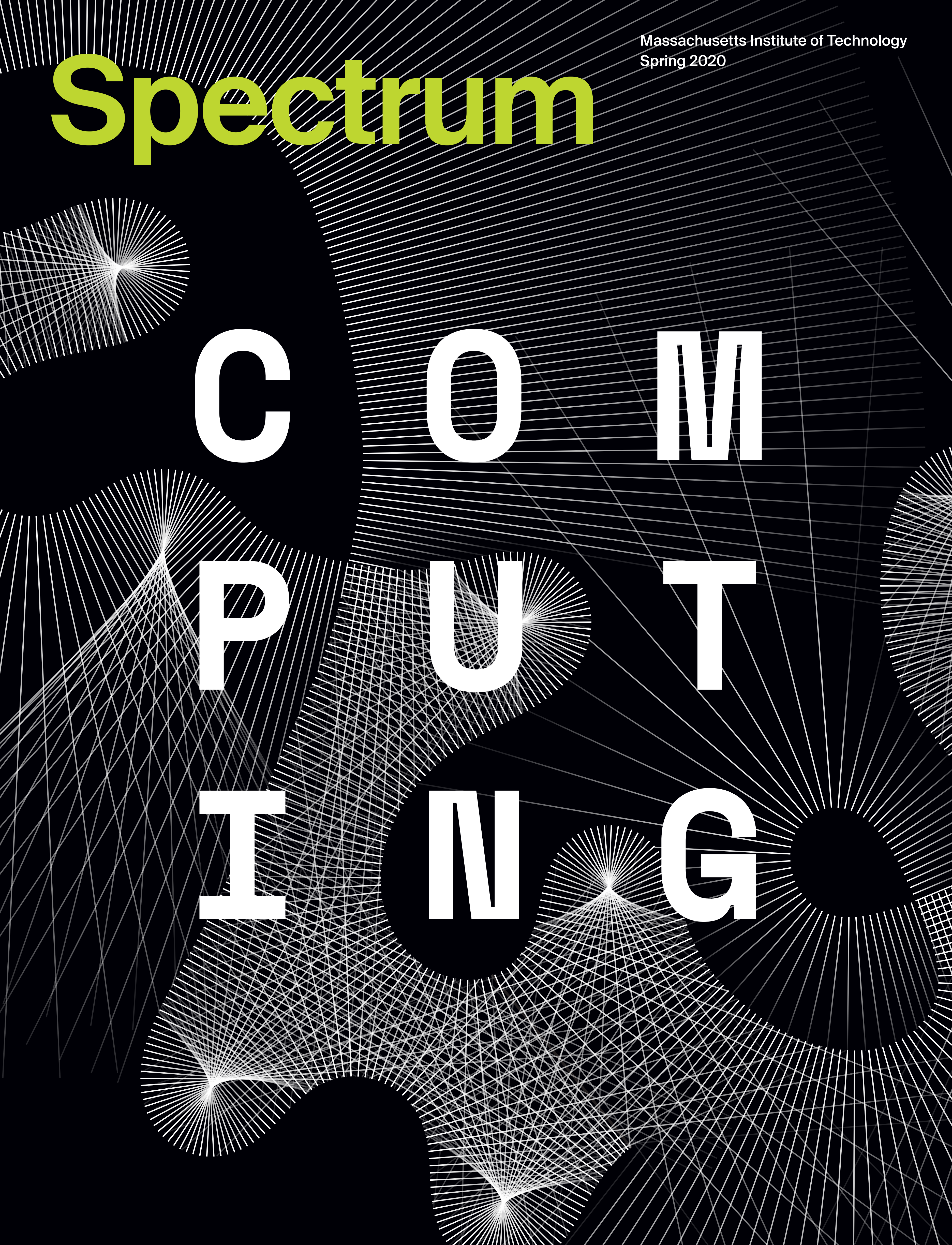
Massachusetts Institute of Technology
Spring 2020

Spectrum



Novel materials designed by Svetlana V. Boriskina exhibit frequency-selective light scattering, creating colors the way butterflies do. A research scientist in the Department of Mechanical Engineering, Boriskina used advanced numerical algorithms and machine-learning techniques to design these materials—one of the many ways computational tools are impacting disciplines across MIT.

IMAGE: COURTESY OF SVETLANA V. BORISKINA

Wide Angle

Subjects

SPECIAL SECTION

Computing

Breakthroughs and Insights

Inside the MIT Campaign for a Better World

FRONT COVER

Generative forms created by artist Zach Lieberman, adjunct associate professor of media arts and sciences at MIT, using openFrameworks, an open-source C++ toolkit. Lieberman often explores the relationships between geometry, order, disorder, curves, and other primitive forms using software and simulation.

ILLUSTRATION: ZACH LIEBERMAN

Spring 2020

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

The Power to Shape the World

Note: With this issue about to go to press, Covid-19 has just been classified a pandemic. Much of the bold, exciting work described in these pages has been put on hold. There is no telling how long it will be before campus life can return to normal. But you will not be surprised to hear that the MIT community is meeting the challenges of each day with strength, resilience, selflessness, and grace. —LRR

Computing is often compared to electricity, another technology with the power to radically alter society and culture. Before artificial light and power were available on demand, no one could have imagined how much they would transform modern life.

Today, computing is reshaping our world in equally exciting and unpredictable ways. There is tremendous enthusiasm for the intellectual opportunities created by computing and artificial intelligence (AI), not only in science and engineering, but in all disciplines.

With the opening of the MIT Stephen A. Schwarzman College of Computing, the Institute embarks on a journey to shape the future of computing. Over the past several years, our students have flocked to classes in AI, machine learning, programming, and data science. The college will enable us to ensure graduates have the tools they need to be successful in these fields—and to apply computing skills to any discipline they choose.

We also take very seriously our responsibility to prepare those who will develop and deploy new technologies to think deeply about the ethical implications and societal impacts—and to act wisely. Integrating the wisdom of the social sciences, arts, and humanities will be vital to the success of this new enterprise.

There is no blueprint for this. The college is an entirely new entity. Under the leadership of Dean Daniel P. Huttenlocher SM '84, PhD '88, we are bringing together inspiring leaders and faculty to develop new programs, courses, and affiliations.

A new building, on the site of the current Building 44, will open as early as 2023, creating an interdisciplinary hub where faculty and students can meet and share ideas. But the college will not primarily be a physical place. Its strength will lie in its potential to connect people across campus and beyond, creating new pathways for interdisciplinary inspiration, collaboration, and discovery.

As the people of MIT help shape the future of computing, what they discover and invent promises to be electrifying.

Sincerely,

L. RAFAEL REIF

(↗)
LEARN MORE
betterworld.mit.edu

The Hive was created by:

- Undergraduate Association Committee on Sustainability
- Office of Sustainability
- Grounds Services

With mentorship and support from:

- Committee for Renovation and Space Planning
- School of Architecture and Planning

The Hive garden, located on the Saxon Lawn at the corner of Ames Street and Memorial Drive, offers a place to collaborate, reflect, and learn about sustainability at MIT and beyond.

The Hive garden hosts a plant palette of nearly 40 unique varieties chosen for their diverse visual appeal and to attract and support pollinators. The plantings include bee balm, a favorite of hummingbirds and bees, and aromatic blue aster, whose blue-purple daisy-like flowers attract bees and butterflies.

Norm Magnuson, manager of Grounds Services, demonstrates proper plant care to Jennifer Fox '21. The Hive garden is cared for by both students and Grounds Services staff.

The space is furnished with wooden chairs handcrafted by architecture student and MIT Office for Sustainability design fellow Effie Jia '20. There is also a picnic table in the shape of a hexagon that, together with the similarly shaped planters, resembles a honeycomb.

Engineering students Samuel T. Nitz '21 and Vivian Song '20 enjoy the space.

Hive Mind

In true MIT collaborative spirit, five campus organizations have come together to create a first-of-its-kind space at MIT—an urban garden named the Hive, which is designed to attract the kinds of pollinators that are fundamental to sustainable ecosystems and food systems.

In 2017, members of the MIT Undergraduate Association Committee on Sustainability pursued an opportunity to launch a large-scale project on campus. The committee generated multiple ideas and then polled the undergraduate population, which voted for a collaboratively designed and maintained garden. This idea became a reality this past September, with the additional goals of educating and engaging students in sustainability efforts, providing a community gathering space, and offering a supportive environment for bees, birds, butterflies, and moths.

"We envision the garden functioning as an observational tool to explore important questions about our environment," says Susy Jones, senior project manager at the MIT Office for Sustainability, who worked closely with the students and supervised the project. "We can ask: How do our plants respond to stress from extreme weather events? When do they flower year over year? Which plants attract the most bees? We look forward to exploring these questions with students, researchers, and community members."

Collaborators are equally excited to see how the garden will impact the MIT community, from serving as a peaceful reading space to a place to share a meal and chat. In the warm months, they expect the space to be buzzing with activity from students, as well as from birds and insects.

"Our hope is that the Hive will serve as a model for future urban gardens, both on the MIT campus and elsewhere," says Julie Newman, director of sustainability at MIT. "Ideas from students include integrating water capture, solar energy, and public art into open spaces like this on campus."

Meanwhile, students who helped build the Hive began designing and building interpretative signs for the garden this winter, hoping to have them ready for spring. "That's been part of the student learning experience—how do you communicate the value of the garden, tell the story, engage passersby in science and ecology, and activate this outdoor site as a place of learning?" says Jones. By consulting with partners in campus operations and makerspaces on the physical process of building signage, this project takes on yet another cross-disciplinary component, paralleling the diverse natural ecosystem of the garden. —Amy Mackin

PHOTO: M. SCOTT BRAUER

Twenty Years of Global Thinking

MIT Sloan's biggest Action Learning lab opens door to world of entrepreneurship

TITLE

15.389 Global Entrepreneurship Lab

INSTRUCTORS

Simon Johnson PhD '89
Ronald A. Kurtz Professor of Entrepreneurship; Professor, Global Economics and Management; Cofounder, Global Entrepreneurship Lab

Michellana Jester
Lecturer, Global Economics and Management

FROM THE CATALOG

The Global Entrepreneurship Lab (G-Lab) is a graduate-level class in the MIT Sloan School of Management focused on the experiential study of the climate for innovation and determinants of entrepreneurial success. Students work in teams of four with the top management of a company to address a real-world business challenge, gaining insight as to how companies build, run, and scale a new enterprise. The projects focus primarily on startups operating in **emerging markets**. G-Lab is the largest of MIT Sloan's Action Learning labs, which emphasize the Institute's philosophy of practical education and learning by doing.

Jester: "We'll be in anywhere from 12 to 16 different countries. The industries are very different, so challenges can be fairly nuanced."

HOW IT WORKS

G-Lab brings second-year MIT Sloan MBA students together to work with companies in emerging markets in regions such as Latin America, Africa, the Middle East, and Southeast Asia. The relationship is mutually beneficial: companies get the expertise students have generated throughout their first year at MIT Sloan, and students get to put their coursework and past **experience into practice** to solve a real-world business problem.

Kelsey Sommers MBA '20, working in Vietnam with The Coffee House: "Taking an Action Learning course like this is a great way to actually be making a tangible difference."

Over the summer, small-scale companies submit proposals to G-Lab outlining challenges they are facing in their businesses. They might be interested in new ways to scale their inventory, for example, or hope to take advantage of social media to break into new markets. At the start of the fall semester, **teams are matched** with businesses based on an evaluation of both the students' areas of interest and the businesses' immediate needs.

Johnson: "This part, for the students, is a conscious effort to explore the world and to find ways to be helpful to people in very different business and cultural contexts."

Teams are also assigned mentors—MIT lecturers with some combination of deep country, industry, or domain experience. The highlight of the course comes during January's Independent Activities Period, when the teams work in their companies' home countries to **test and implement** the recommendations they have constructed during the fall term.

Lea Daigle MBA '20, working in Peru with the bakery Mária Almenara: "My favorite thing is [working] with a company in a market and on a problem that I may never have the opportunity to work on again."

WEEK TO WEEK

The first few weeks of the term consist of lectures about special considerations in emerging markets. Students learn how to work within different political systems and about the ins and outs of securing funding and other resources in diverse cultures across the world. From there, teams begin to workshop their challenges. Along the way, they maintain frequent contact with their assigned businesses to ensure that the solutions they are devising—anything from a digital dashboard for decision-making to a detailed expansion plan—will meet the companies' stated needs.

Successful entrepreneurs share their experiences in a series of guest lectures throughout the semester. Students in fall 2019 heard from Adrian Garcia-Aranyos, president of Endeavor Global, and Adetayo Bamiduro MBA '15, a G-Lab alum who began the motorcycle transit startup MAX.NG in Nigeria.

Kelsey Sommers MBA '20 says, "Taking an Action Learning course like this is a great way to actually be making a tangible difference."

Teams present their work twice: in an open mic-style session midway through the semester and in a longer, more formal setting during the last few weeks of class. In both cases, other MIT Sloan students, MIT faculty, and staff are invited to provide commentary intended to strengthen and solidify the proposed solutions before teams travel abroad.

In January, the students spend three weeks on site with their companies to conduct primary research, test their hypotheses, fine-tune their work, and **deliver final recommendations**. When they return to MIT at the start of the spring semester, students attend an informal reflection session to discuss their respective in-country experiences.

Jester: "They need to come up with an immediately actionable solution to the company's challenge, not a nice coffee table book."

HISTORY

G-Lab was founded in 2000 in response to student requests for hands-on work with companies in emerging markets. Using the existing Entrepreneurship Lab as a jumping-off point, Johnson, along with then-MIT professor Richard Locke PhD '89, designed G-Lab to give students opportunities to stretch their skills in unfamiliar markets and locations. The class was wildly popular; at its height, 180 students were enrolled. The class has since limited enrollment to 120 students to maintain intimacy between groups and mentors, but it remains the **largest Action Learning course** at MIT Sloan.

Jester: "It's an inter-disciplinary approach to a real-world business challenge, and that opportunity makes the course very attractive."

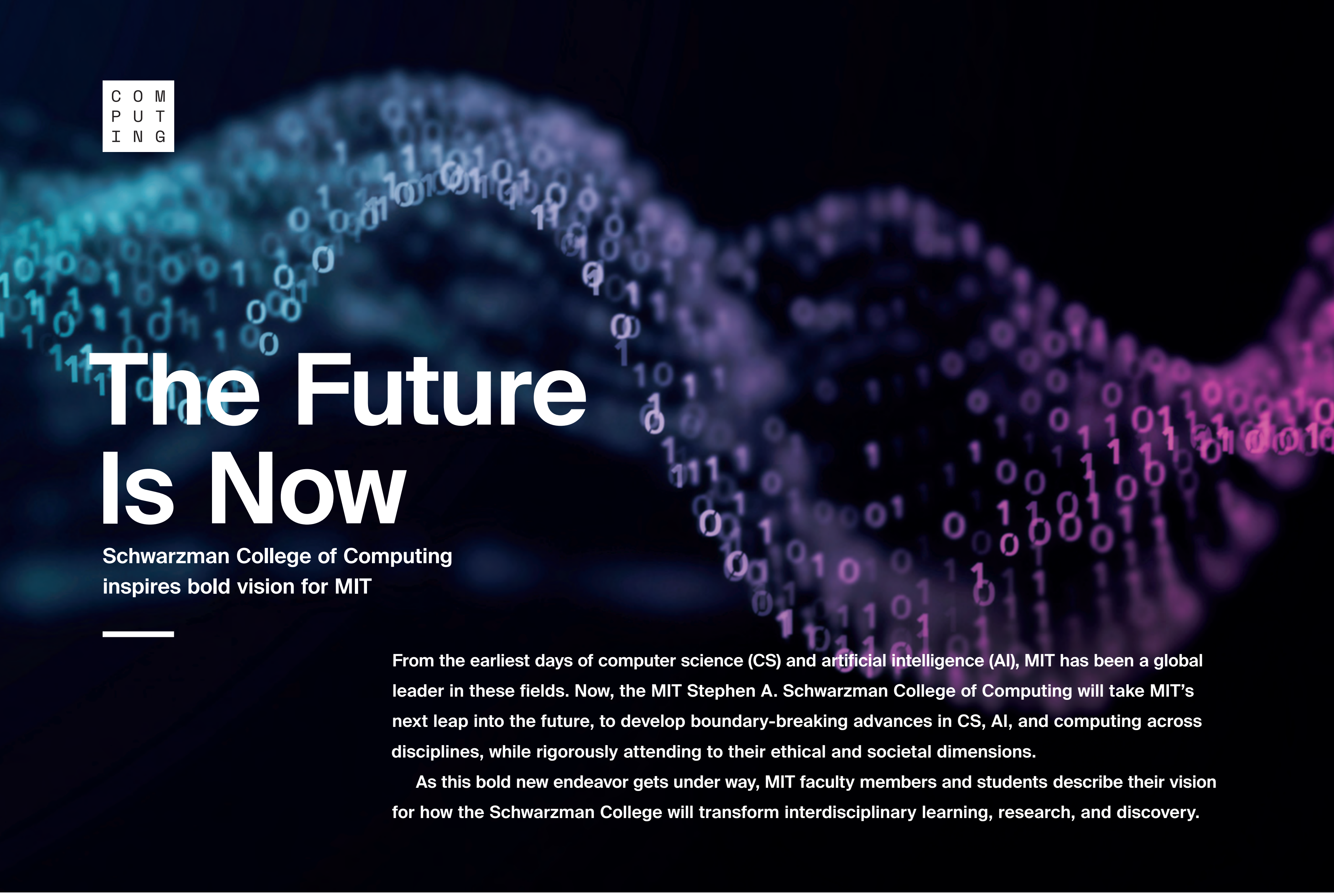
Instructors Michellana Jester, top, and Simon Johnson PhD '89, right, guide MBA students through the basics of doing business in emerging markets.

PHOTOS: M. SCOTT BRAUER

COMPUTING

Computing has become as indispensable as running water and electricity, and it is powering societal changes as sweeping as those of the first Industrial Revolution. As computing revolutionizes how people work, play, learn, and interact, the new MIT Stephen A. Schwarzman College of Computing is transforming the Institute to meet emerging challenges. Bridging disciplinary boundaries, the college draws great minds together to consider the societal and ethical challenges that lie ahead and to seize the extraordinary global opportunities offered by advanced computing and artificial intelligence.

ILLUSTRATION: ZACH LIEBERMAN



The Future Is Now

Schwarzman College of Computing inspires bold vision for MIT

From the earliest days of computer science (CS) and artificial intelligence (AI), MIT has been a global leader in these fields. Now, the MIT Stephen A. Schwarzman College of Computing will take MIT's next leap into the future, to develop boundary-breaking advances in CS, AI, and computing across disciplines, while rigorously attending to their ethical and societal dimensions.

As this bold new endeavor gets under way, MIT faculty members and students describe their vision for how the Schwarzman College will transform interdisciplinary learning, research, and discovery.

Commentators

Eran Ben-Joseph is a professor of landscape architecture and urban planning. His research and teaching include urban and physical design, standards and regulations, sustainable site planning technologies, urban retrofitting, and public interest technology.

James DiCarlo is the Peter de Florez Professor of Neuroscience, head of the Department of Brain and Cognitive Sciences, an investigator at the McGovern Institute for Brain Research at MIT, and a co-director of MIT's Quest for Intelligence. His research centers on understanding the neuronal representations and computational mechanisms that underlie visual object recognition in primates.

Eden Medina PhD '05 is an associate professor in the Program in Science, Technology, and Society in the MIT School of Humanities, Arts, and Social Sciences. Her research explores technology as a means to understanding historical processes. She is particularly interested in the history of science and technology in Latin America and the ways that political projects shape—and are shaped by—technology.

Asu Ozdaglar SM '98, PhD '03, is deputy dean of academics for the MIT Schwarzman College of Computing, head of the Department of Electrical Engineering and Computer Science (EECS), and the School of Engineering Distinguished Professor of Engineering. She is affiliated with the Laboratory for Information and Decision Systems and the Operations Research Center. Her research focuses on problems that arise in the analysis and optimization of large-scale dynamic multiagent networked systems, including communication networks, transportation networks, and social and economic networks.

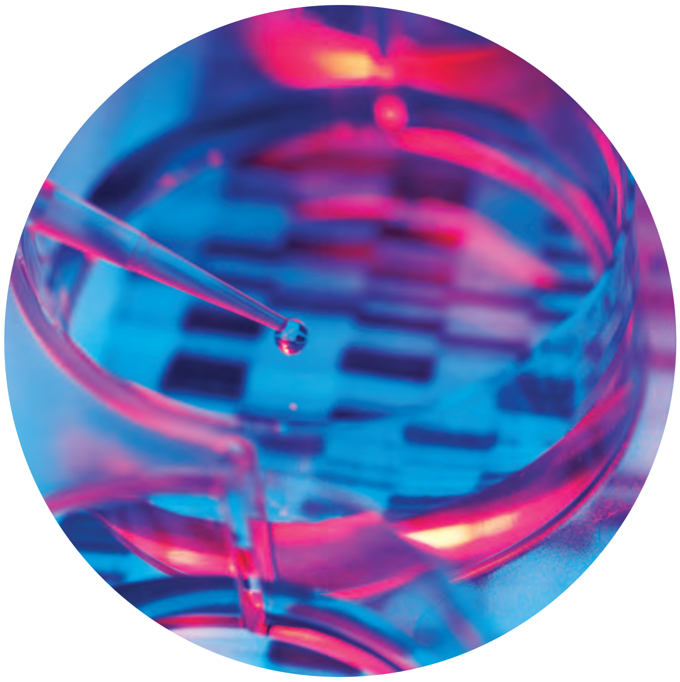
Aman S. Patel '20 recently completed his undergraduate studies in computer science and molecular biology with a particular interest in machine learning and data science as applied to biology and health care. He is now pursuing a master's degree at MIT. Patel has been a Landsman Undergraduate Research and Innovation Scholar in MIT's Advanced Undergraduate Research Opportunities Program. He is also a research intern at the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL).

Georgia Perakis is the William F. Pounds Professor of Management at the MIT Sloan School of Management. As a professor of operations research/statistics and operations management, and co-director of the Operations Research Center, Perakis teaches and conducts research on analytics, optimization, revenue management, supply chains, energy, and health care. Her goal is to help enterprises and individual leaders understand and utilize the power of data.

Daniela Rus is the deputy dean of research for the Schwarzman College, director of CSAIL, and the Andrew and Erna Viterbi Professor of Electrical Engineering and Computer Science. Her research focuses on robotics, mobile computing, and data science.

Harini Suresh '16, MNG '17, is a doctoral candidate in computer science in EECS. Her research centers on the societal implications of machine learning, including deep-learning approaches to machine-guided medical decision making. Her goal is to make these automated systems easier to understand and to use responsibly.

Mattie F. Wasiak '20 is a master's candidate in computer science with an artificial intelligence concentration. Wasiak, who recently completed an SB in computer science at MIT, is applying machine learning and statistical techniques to challenges such as optimization of patient care in neonatal intensive care units, detection of employer bias in job postings, and improved patient outcomes in treating sepsis and hypertension.



How does the Schwarzman College of Computing leverage existing strengths at MIT and fuel new forms of interdisciplinary learning and collaboration?

SURESH: The college offers new incentives and opportunities to develop the computer science field—and computing applications in many different fields—thoughtfully and responsibly. MIT has a lot of influence, and we can demonstrate that it is both important and possible to commit time, space, and resources to teaching and researching computing in a way that incorporates ethical and societal considerations.

BEN-JOSEPH: The Schwarzman College means we can conduct research that examines the complexities of society's relationship with new and expanding computational technologies, including issues of access and unintended negative consequences. It is a true collaborative and interdisciplinary hub that brings together unique MIT faculty who focus on the use and evolution of computing in artful and impactful ways, across many fields.

PERAKIS: What excites me about the Schwarzman College is that it will bring together people from across the Institute working in computing as it connects to predictive and prescriptive analytics, which involve extracting information from big data and using that information to create recommendations and predictive models. The new college gives MIT a great opportunity to utilize economies of scale and solidify our leadership in these areas.

WASIAK: I anticipate that the college will give researchers and students at MIT new, concrete opportunities to accelerate research in artificial intelligence and machine learning by drawing together individuals from diverse disciplines, such as health care and computer science.

The new Schwarzman College of Computing draws on people and resources across MIT to advance computing and shape its impact on research, education, and the world.

PHOTOS (CLOCKWISE FROM TOP LEFT): MR.COLE_PHOTOGRAPHER; ANDREW BROOKES; © GREENBUTTERFLY

"This new endeavor requires us to break out of our research silos and collaborate in ways that go well beyond the boundaries of business as usual. That's really what MIT is all about," DiCarlo says.

RUS: Our scholars are laying the theoretical foundations of computing and applying those foundations to big ideas in computing and across disciplines. Some are even starting businesses based on their research.

MEDINA: I hope the college will change how our students approach questions of human-computer interaction. Studying how people use and interact with computer systems is important, but so is thinking about computers as part of a larger set of organizational, governmental, and community relationships. This sociotechnical approach broadens our understanding of how humans and computers interact and the ethical and policy implications of these interactions.

DICARLO: Breakthrough advances often come when people make a concerted effort to take on challenges that were previously deemed "in the future." This new endeavor requires us to break out of our research silos and collaborate in ways that go well beyond the boundaries of business as usual. That's really what MIT is all about, and I believe that the Schwarzman College within the MIT ecosystem will nucleate this—and many other—unprecedented, concerted efforts.

How will the Schwarzman College of Computing empower your research—and your field?

RUS: One example is a collaboration we launched between the Schwarzman College and the US Air Force. The goal is to make major advances in AI both to improve Air Force operations and address larger societal needs. There are 15 funded projects that will address a

variety of topics, including foundational aspects of machine learning, new systems architectures for machine learning, optimization for scheduling and task allocation, weather prediction, autonomous vehicles training and control, and medical readiness.

DICARLO: My lab's work in visual object recognition and perception employs a "reverse-engineering" approach, which means that we use engineered neural networks, simulated on computers, as our alternative hypotheses or models for human visual processing. We then select among them using neural and behavioral data to discover even better models. My colleagues and I believe that strengthening our connections to MIT engineering and computing through the new college will allow us to generalize this reverse-engineering approach to other brain systems and other types of computational models, leading to major breakthroughs in human cognition, language, and emotional intelligence as well as in understanding the parallels and differences between human learning and machine learning.

OZDAGLAR: The college has an ambitious and holistic agenda for research in computing and at its intersections with several other disciplines. My group's research focuses on several aspects of human-computing interactions. For example, we look at how digital platforms may improve economic, financial, and social decisions. Conversely, we consider how human decisions may lead to market failures or strategic manipulation could result in platform malfunctions.

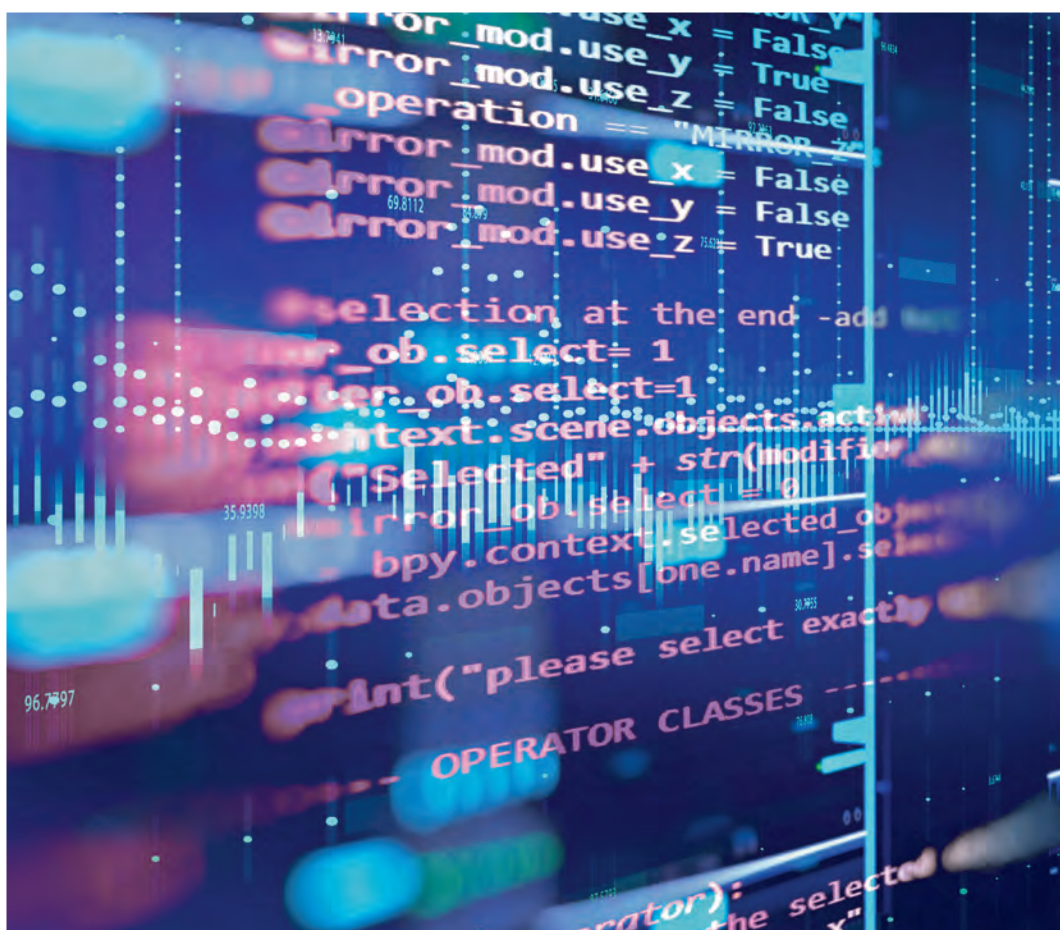
WASIAK: The Schwarzman College promises to advance data science, which is central to the work I do. My research leverages massive amounts of data from Beth Israel Deaconess Medical Center to find potential factors that may be affecting how often preterm infants leave their optimal oxygen saturation range. These insights will help close the loop between the researchers and clinicians.

PERAKIS: The focus of my research is developing predictive and prescriptive computational models and algorithms, with applications that range from retail to the energy sector, as well as how they relate to nonprofit organizations and health care. One of my current collaborations is with Lahey Clinic and is focused on addressing the opioid crisis by predicting overdose and prescribing the right treatment path for patients, in both holistic and personalized ways. The new college should advance work like this, which can have a positive influence on individual outcomes and on health care policy.

PATEL: Much of my work is in the field of computational biology, which entails using computational techniques to solve important biological problems. For example, computational biology has allowed us to make more effective patient diagnoses and gain a clearer picture of our underlying genetic regulatory mechanisms, among a multitude of other applications. Although MIT is already an established leader in the field, I believe the Schwarzman College will enable us to have even greater impact.

MEDINA: As a historian of technology who studies the relationship of computer technologies to processes of political change, I am excited that the college has made the social and ethical responsibilities of computing part of its organizational structure. This commitment is central to teaching, but it also highlights an important and growing area of research and an opportunity to broaden the kinds of questions and methods used in the study of computing.

BEN-JOSEPH: My colleagues and I aim to drive urban science and computer science forward to integrate ethics, justice, public participation, policy, and design with statistics, data science, geospatial analysis visualization, robotics, and machine



learning to craft equitable and innovative solutions to tomorrow's complex urban problems. The result: a new generation of data science, AI, and technology focused on solving the profound challenges posed by urbanization—and one that will be optimized to better serve the public interest.

What big questions do you want to see the college tackle?

MEDINA: The famed MIT mathematician Norbert Wiener remarked that instead of celebrating our technical know-how, we should give greater attention to questions of "know-what," or what we want—and don't want—our technologies to do. In an age of deep fakes, ubiquitous data collection, and the weaponization of social media platforms to promote misinformation, intolerance, and violence, it seems we need to be asking more "know-what" questions about technology.

OZDAGLAR: A distinctive feature of the college is its explicit focus on social impacts of computing. This motivates our broader community to investigate how advances in computing and AI will impact the work of the future and other societal priorities.

RUS: The college will expand and deepen the connection between computing and other disciplines. With an approach MIT President L. Rafael Reif calls "creating bilinguals," our students will be equipped to help us answer some of the major questions facing our field and our world. –Kris Willcox

As computing transforms every discipline, from music and brain science to economics and urban studies, the Schwarzman College of Computing will work to address emerging opportunities and challenges.

PHOTOS (CLOCKWISE FROM TOP LEFT): © IPOPBA; © JAMESTEOHART; © MONSITJ; WAVEBREAK MEDIA

What might we achieve through the Schwarzman College?

"Open-source data sets that maintain patient confidentiality."

Wasiak

"Harnessing the power of technology and computer science to understand and solve the challenges of the global phenomenon of urbanization."

Ben-Joseph

"New academic programs, diverse faculty hires, and an environment where cross-disciplinary work is important and necessary."

Suresh

"Advances in computing in all of its dimensions, ranging from algorithms, numerical methods, systems, artificial intelligence, machine learning, and the hardware of computation."

Ozdaglar

"Dramatic advances in AI, machine learning, and a deep, engineering-level understanding of human intelligence."

DiCarlo

Computing College Forms Bit by Bit

Schwarzman College leadership discuss MIT's mission to harness tech advances for good

What is it like to create a whole new cross-cutting academic entity at MIT, one that will impact nearly everyone on campus while attempting to meet the broad needs of the computing field, our era's major technological force?

MIT Stephen A. Schwarzman College of Computing (SCC) dean Daniel Huttenlocher SM '84, PhD '88 compares the process to modern product development, where companies launch early versions to market, take in feedback, and iterate—enabling new products to evolve quickly.

"We are building this plane and flying it at the same time," he says. "I don't think we know enough now to build the full thing. The way we'll learn is by trying things out and being flexible to continued change."

Still, less than a year and a half after MIT announced the gift establishing the SCC, the groundbreaking new entity is already taking shape. The college has a deputy dean for research, another for academics, and two associate deans of the Social and Ethical Responsibilities of Computing (SERC) (see story on page 22). The college also has incorporated a number of new and existing academic programs.

The college stands in a unique position spanning MIT's five existing schools, the School of Architecture and Planning; the School of Engineering; the School of Humanities, Arts, and Social Sciences (SHASS); the MIT Sloan School of Management; and the School of Science. It represents the first major structural change since the early 1950s, when SHASS and MIT Sloan were established.

"As humanity works to solve problems ranging from climate change to...eliminating poverty, computing opens the door to powerful new solutions," Rus says.

College leaders, from left: David Kaiser, Julie Shah, Daniel Huttenlocher, Asu Ozdaglar, and Daniela Rus.

PHOTO: SARAH BASTILLE

By both supporting and drawing strength from the five schools, the college will address three major challenges: meeting the exploding need for computer science, artificial intelligence, and related computing research and education; facilitating the bidirectional movement of knowledge between computational fields and other disciplines; and forging a path toward more socially and ethically responsible computing, both at MIT and in the greater world.

"As humanity works to solve problems ranging from climate change to curing disease, removing inequality, ensuring sustainability, and eliminating poverty, computing opens the door to powerful new solutions," says SCC deputy dean of research Daniela Rus, who is also director of the Computer Science and Artificial Intelligence Laboratory (CSAIL) and the Andrew and Erna Viterbi Professor in the Department of Electrical Engineering and Computer Science. "With the Schwarzman College of Computing as our foundation, I believe MIT will be at the forefront of those solutions."

Computing fields

Initially, SCC leaders plan to address the huge demand for, and the rapidly changing content of, undergraduate and graduate computing education: 40% of undergraduates major in computer science, but only 7% of faculty have appointments in that field.

COMPONENTS

The following MIT departments, institutes, labs, and centers are now part of the MIT Schwarzman College of Computing.

- **Department of Electrical Engineering and Computer Science**
- **Operations Research Center, jointly part of the Schwarzman College and MIT Sloan School of Management**
- **Institute for Data, Systems, and Society, which will be increasing its focus on the societal aspects of its mission while continuing to support statistics across MIT, and including the Technology and Policy Program and Sociotechnical Systems Research Center**
- **Center for Computational Science Engineering, formerly the Center for Computational Engineering, is broadening its focus in the sciences**
- **Computer Science and Artificial Intelligence Laboratory**
- **Laboratory for Information and Decision Systems**
- **MIT Quest for Intelligence**
- **Abdul Latif Jameel Clinic for Machine Learning in Health**
- **MIT-IBM Watson AI Lab**

"Many students have interests and passions beyond computer science but want to be fluent in computing techniques and methodologies," says Asu Ozdaglar SM '98, PhD '03, deputy dean of academics for the college, head of the Department of Electrical Engineering and Computer Science, and the School of Engineering Distinguished Professor of Engineering.

To enhance computing across the curriculum, the SCC is creating the Common Ground for Computing Education, an interdepartmental teaching collaborative. This entity will support new pedagogical partnerships and provide a shared resource for faculty who teach similar topics, such as numerical computing, in different disciplines.

Additionally, the SCC will support ambitious research to advance computing itself. "We have goals in core aspects of computing—like developing approaches to software and hardware that can dramatically improve computing capabilities over the next 50 years, using computation to understand comprehensibly human intelligence, and creating hack-free security systems," says Rus. She is coordinating the college's research units, including CSAIL, the MIT Laboratory for Information and Decision Systems, and the MIT Quest for Intelligence (for more on the Quest, see page 26).

Computing in other disciplines

The SCC's mandate is much broader than computer science and artificial intelligence, because computing is now integral across all five MIT schools. "Computing is transforming intellectual inquiry in almost every discipline," Huttenlocher says. "At the same time, those disciplines are starting to affect research and education at the core of computing and the ways people think about computing."

Ozdaglar describes the questions driving researchers across MIT as "bidirectional." "It's not just using computing techniques, methodologies, and data science in social science, but also social science questions and insights that are informing the development and design of technologies by computer scientists. That's something the college is taking very much head-on," she says.

For example, political science and linguistics now rely heavily on computing for data analysis. And computer scientists find they can benefit from humanistic insights for such tasks as incorporating human decision making into online platform design.

The SCC will therefore foster cross-cutting research and educational paths, notably by supporting new and existing blended majors such as Course 6-14, which combines computer science, economics, and data science. "What the blended majors have done is enable students to be skilled in computer science but also to pursue their passions in other areas—whether it be economics or urban science or something else," Ozdaglar says.

The SCC influence on the undergraduate experience will go far beyond such majors, however, since essentially every MIT student gets some computing instruction. SCC leaders are carefully considering "what kinds of questions and materials and sets of considerations do we want to make sure students are encountering at some level multiple times" during their undergraduate years, says SERC's associate dean David Kaiser, the Germeshausen Professor of the History of Science and professor of physics.

Broader impacts and responsibilities of computing

Computing's very power and ubiquity does raise concerns—about job security, privacy, military applications, and beyond—that matter to engineers, scientists, artists, and humanists alike. However, people in diverse fields often approach these concerns differently. That's why one of the college's primary missions is to convene disparate thinkers to address computing's enormous impacts—not just at MIT but in the larger world.

"There's sometimes less immediate overlap in methods, approaches, or ways of framing questions between the humanistic disciplines and computing or engineering approaches more broadly," Kaiser says. The SCC's goal is to find commonalities. "It's an exciting challenge. What does it take to get people in a room together who aren't often in a room on a regular basis?"

The ambitious, overarching vision is to "actively weave social and ethical considerations into everything we're doing," says SERC associate dean Julie Shah '04, SM '06, PhD '11. "Traditionally, many of us technologists aren't trained to pause and envision the possible futures for how our tech can and will be used. We need new habits of mind and action."

SERC will establish best practices and disseminate them, informing policy and practice in government and industry. "If we just do this as an academic exercise, it's not enough," Huttenlocher says.

Two more elements of the college will ultimately support this broader impact mission. An assistant or associate dean of equity and inclusion will be brought onboard to help broaden participation in computing classes and degree programs and bolster the diversity of graduate students and faculty candidates in computing fields.

Looking ahead, a Center for Advanced Studies of Computing is planned to seed new scholarly, educational, and policy projects via project-oriented semester- or yearlong programs co-led by MIT faculty, with "fellows" from within and beyond MIT. —Kathryn M. O'Neill

EECS Restructured

As part of the founding of the MIT Stephen A. Schwarzman College of Computing, the Department of Electrical Engineering and Computer Science (EECS) has been restructured to enhance existing programs, create new opportunities, and increase connections to other parts of the Institute.

EECS, the largest academic unit at the Institute, is now jointly part of the MIT School of Engineering and the MIT Schwarzman College of Computing. It is composed of three overlapping academic units called "faculties": electrical engineering (EE), computer science (CS), and artificial intelligence and decision making (AI+D). The department will remain responsible for Course 6.

"We expect the creation of these three more focused faculties within the department will facilitate curriculum development, faculty hiring, and collaborations across campus and across disciplines," says Daniel Huttenlocher SM '84, PhD '88, dean of the college. "The faculties will focus on faculty recruiting, mentoring, promotion, academic programs, and community building," added Anantha P. Chandrakasan, dean of the School of Engineering and the Vannevar Bush Professor of Electrical Engineering and Computer Science.

Joel Voldman SM '97, PhD '01, a professor of electrical engineering and computer science, has been tapped to lead the EE faculty. Arvind, the Jennifer C. Johnson Professor of Computer Science and Engineering, is heading CS. Antonio Torralba, the Thomas and Gerd Perkins Professor of Electrical Engineering and Computer Science, is leading the AI+D faculty.

The three faculty leaders will contribute to the overall leadership of EECS under the direction of Asu Ozdaglar, School of Engineering Distinguished Professor of Engineering. As the newly appointed deputy dean of academics for the college, she also serves as the head of EECS. The three faculty leads and Ozdaglar will report jointly to Huttenlocher and Chandrakasan.

The organizational plan for EECS was based on the final report of the Organizational Structure Working Group of the Computing Task Force.

PHOTOS: LILLIE PAQUETTE (OZDAGLAR AND TORRALBA); JASON DORFMAN (ARVIND); GRETCHEN ERTL (VOLDMAN)

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computing.mit.edu

Dropbox Founder Envisions the Future Workplace

Drew Houston ’05 wants AI tools to free our minds

Drew Houston ’05 is on a mission to create a better world—of work. Few would argue he made a great start when he launched Dropbox. Cofounded with MIT classmate Arash Ferdowsi in 2007, Dropbox today helps 600 million people around the world share and keep track of files.

Now that Houston is CEO of one of the world’s leading business collaboration platforms with 2,300 employees and 12 offices, he says he has become increasingly frustrated with the inefficiency of the modern workplace. That’s one reason he made an early gift in support of the MIT Stephen A. Schwarzman College of Computing. His gift supports the hiring of a chaired faculty member in the college and the MIT Sloan School of Management who pursues research at the intersection of computer science and management science. It also provides the college’s inaugural dean, Daniel Huttenlocher SM ’84, PhD ’88, with flexible start-up funding.

Advances in computing, especially those related to artificial intelligence (AI) and machine learning, hold great promise for transforming workplaces for the better, Houston says.

“I’m proud to see MIT leading from the front, making ambitious investments like the one in this college.”

Houston explains that he’s particularly concerned about productivity loss caused by “work about work,” the estimated 60% of time that knowledge workers spend on tasks such as finding information, checking email, toggling between apps, and coordinating with people and teams around the world.

“Every challenge we have as a society depends on being able to harness our brainpower and do knowledge work well,” Houston says, noting that today’s systems often create roadblocks to humanity’s highest goals. “Brainpower is the fuel for human progress.”

Speaking at the launch of the MIT Schwarzman College of Computing in 2019, Houston outlined a vision for a future in which computers relieve modern workers of much of their busywork, transforming lives the way that the Industrial Revolution did by relieving 18th- and 19th-century workers of many physically burdensome tasks.

“My hope is that in 2030, we’ll look back on now as the beginning of a revolution that freed our minds the way the Industrial Revolution freed our hands,” Houston says. “And that it happens right here. The college will be a place where that revolution is born.”

The college’s focus on computing and AI across all disciplines aligns with Houston’s vision for the workplace of the future, in which, he explains, “we’ll all have an AI copilot.” At Dropbox, he has reimagined the experience of using technology at work, evolving the company from a passive content repository to a living workspace that brings teams’ content together while letting them use the tools they love. Last fall, the company rolled out Dropbox Spaces, the first iteration of his vision, which allows teams to collaborate, receive feedback, track to-dos, and see what they are working on in real time.

Houston

“My hope is that in 2030, we’ll look back on now as the beginning of a revolution that freed our minds the way the Industrial Revolution freed our hands,” Houston says.

In Houston’s view, machine intelligence used well is like having a very smart person cutting through the clutter of the modern workplace, making it possible for workers to get what they need most quickly. Dropbox Spaces, he says, layers machine intelligence to apply deep learning to content, the application ecosystem, and team activity to surface the most relevant content.

Houston believes that content suggestions in Dropbox Spaces help users focus on the truly important aspects of their work and saves them time. “Burnout is a real issue, classified as an occupational phenomenon by the World Health Organization,” he notes. “Some of that burnout results from time spent on busywork that employees don’t really need to do.”

Talk of automation and AI often leads human workers to fear that they could be replaced by machines, and Houston acknowledges this societal concern. “That’s one of the reasons I’m excited about the Schwarzman College,” he says. “We have a lot of smart people at MIT already making progress on that issue.”

On the other hand, he points out, computers are not people. “They don’t have feelings or dreams or a soul or imagination. We have unique abilities that computers won’t be able to match any time soon.”

—Christine Thielman

PHOTO: MATT WINKELMEYER / GETTY IMAGES

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A Fast Track for Machine Learning

Tamara Broderick addresses scaling challenges of Bayesian inference

Machine-learning systems use data to understand patterns and make predictions. When the system is predicting which photos are of cats, you may not care how certain it is about its results. But if it's predicting the fastest route to the hospital, the amount of uncertainty becomes critically important.

"Imagine the system tells you 'Route A takes 9 minutes' and 'Route B takes 10 minutes.' Route A sounds better," says Tamara Broderick, an associate professor in the Department of Electrical Engineering and Computer Science. "But now it turns out that Route A takes 9 minutes plus-or-minus 5, and Route B takes 10 minutes plus-or-minus 1. If you need a life-saving procedure in 12 minutes, suddenly your decision-making really changes."

A high-school outreach program, MIT's Women's Technology Program (WTP), first brought Broderick to campus. "My experience at WTP was formative," she says. Now Broderick studies how machine-learning systems can be made to quantify the "known unknowns" in their predictions, using a mathematical technique called Bayesian inference. "The idea is to learn not just what we know [from the data], but how *well* we know it," she explains.

The catch is that traditional algorithms for "Bayesian machine learning" take a very long time to work on complex data sets like those in biology, physics, or social science. "It's not just that we're getting more data points, it's that we're asking more questions of those data points," says Broderick, who is a principal investigator at MIT's Computer Science and Artificial Intelligence Laboratory and affiliated with MIT's Institute for Data, Systems, and Society. "If I have gene-expression levels for a thousand genes, that's a thousand-dimensional [machine-learning] problem. But if I try to look at interactions between just one gene with another, that's now a million-dimensional problem. The computational and statistical challenges go through the roof."

These challenges impose a bottleneck on using Bayesian machine learning for many applications where quantifying uncertainty is essential. Some complex data analyses might take an infeasible amount of time to run—months or more. And in so-called "high-dimensional" data sets, such as ones with millions of gene interactions, it can be difficult to find the signal among the noise. "It's harder to find out what's really associated with what, when you have that many variables," Broderick says.

In other words, Bayesian machine learning has a scaling problem. Broderick's research devises mathematical work-arounds that reduce computational and statistical complexity "so that our methods run fast, but with theoretical guarantees on accuracy." Her recent work includes techniques with colorful names—"kernel interaction trick," "infinitesimal jackknife"—that evoke a sense of technical wizardry crossed with down-to-earth pragmatism. Indeed, Broderick says she sees scalable Bayesian machine learning as "a service profession" aimed at amplifying the discovery efforts of her fellow scientists.

One such effort came to Broderick's attention from an economist colleague studying how microcredit—small, low-interest loans made to entrepreneurs in developing economies—affects household incomes. "She's interested in finding out whether these small loans actually help people, but it was taking her a really long time to run her experiments with existing Bayesian software," Broderick says. Broderick's team has been developing methods for this work that are both accurate and orders of magnitude faster.

In another collaboration, her team is using Bayesian machine learning to quantify the uncertainty in different kinds of genomics experiments, work that opens the door to a wealth of new, interesting science, Broderick says. This will help biologists use the data they already have to make informed decisions on how to allocate their research funds to best support future work. Think of it as the science-focused version of predicting the fastest route to a hospital with the least uncertainty.

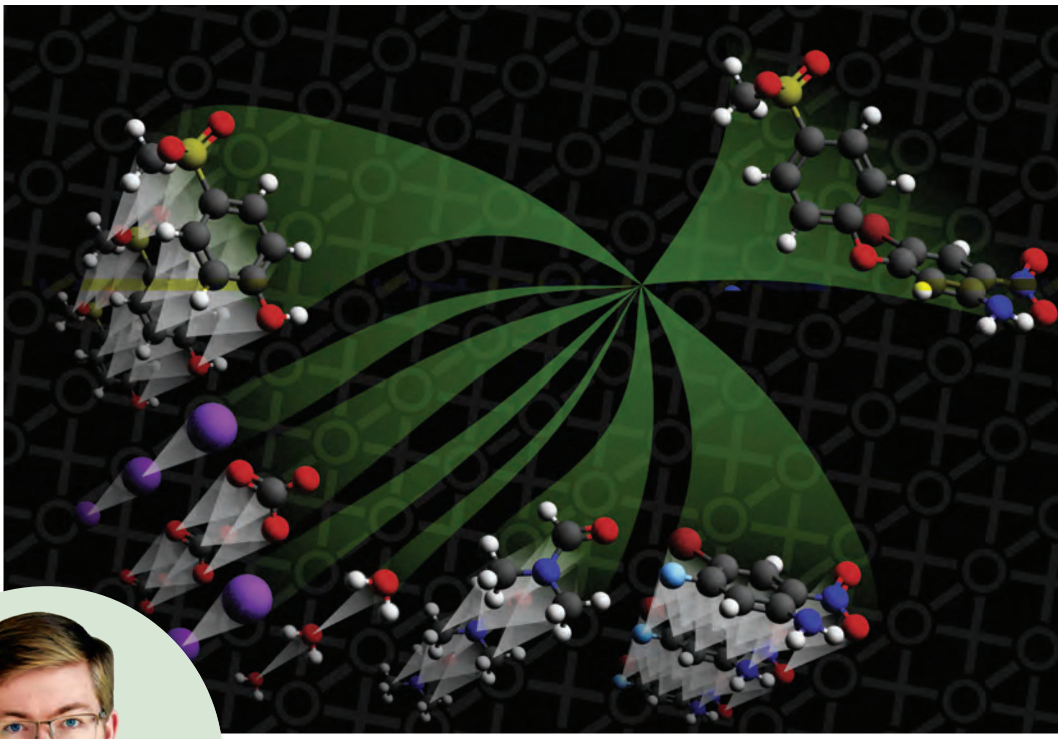
"Even when we're writing a purely theoretical paper, I'd like to think that the theory is very much inspired by problems that arise in people's applications," Broderick says. "We're trying to make science easier for biologists, for chemists, for physicists, so they can focus on their really cool problems and just get the data analysis out of the way." —John Pavlus

Broderick says, "We're trying to make science easier for biologists, for chemists, for physicists, so they can focus on their really cool problems and just get the data analysis out of the way."

PHOTO: SARAH BASTILLE

Computational Tools for Better Chemistry

Connor Coley finds bond between his two passions



Chemistry and computer science may not seem like the most obvious pairing: one conjures the image of a lab-coated and begoggled scientist titrating agents in test tubes and beakers, while the other brings to mind a scientist hunched over a computer, typing code and analyzing vast data sets. And yet, Connor Coley SM '16, PhD '19 is building his career at the interface of these fields, developing algorithms and machine-learning systems to streamline the work chemical engineers do in the lab—tools he hopes can accelerate the process of discovering and synthesizing useful molecules.

"I would consider myself very application-driven," says Coley, who was named to *Forbes*'s 30 Under 30 health care innovators in 2019. "I want to work on problems where I can improve the way that other people are able to approach their own research."

While Coley has always enjoyed coding and programming, he considers these interests secondary to his passion for chemical engineering—his undergraduate major and the focus of his master's degree. It wasn't until Coley started working on his PhD in chemical engineering, supervised by Klavs Jensen, the Warren K. Lewis Professor of Chemical Engineering, and William Green, the Hoyt C. Hottel Professor of Chemical Engineering, that he thought to combine his interests.

Coley was in the lab, building automated reaction platforms that use algorithms to optimize conditions for existing chemical reactions, when he realized that another part of the process could be made more efficient: designing the reactions themselves.

"Once you've figured out what molecular structure you want to make, you still need to come up with a recipe—all the ingredients, all the instructions, all the steps that it will actually take to physically make it," Coley explains. This process requires chemical engineers to draw on published papers, previous experiments, and general chemistry knowledge. "My interest was trying to use that background information in a more principled way."

Coley

Working with group members, Coley has built an algorithm-based, machine-learning system, trained on millions of previously published reactions, that analyzes this background information and offers chemists options and suggestions for making molecules. "It's a way to supplement, not replace, the more traditional approaches," Coley says.

The research has been published in *Science*, and an open-source version of the system is available through MIT's Machine Learning for Pharmaceutical Discovery and Synthesis Consortium. This version has been adopted by chemists and chemical engineers in industry and academia, many of whom conduct pharmaceutical research. "A lot of the molecules that we think about are or one day could be drugs," Coley says.

Now a postdoctoral researcher at the Broad Institute of MIT and Harvard, Coley has temporarily shifted his focus to molecule discovery using a technology called DNA-encoded libraries. In this approach, Coley explains, chemists put millions of DNA-tagged compounds in a tube and simultaneously screen those compounds to see which ones have the greatest affinity for a target—for example, a protein linked to a disease. A selection process then identifies the molecules most inclined to "stick" to the target, measured through DNA amplification and sequencing. Chemists typically look only at measurements related to those top molecules, ignoring the rest.

Coley wants to improve this process by developing computational tools that can sift through the entire collection of measurements and pull out anything that may improve the design of molecules selected for development. "If we have a better understanding of all the different molecular structures that correlate with affinity to our protein, it will be easier for us to tweak the other properties that matter," Coley says.

Whatever the future brings, Coley knows his next step: in fall 2020 he will become an assistant professor in the Department of Chemical Engineering. "MIT is a very fun ecosystem to be a part of," a place that recognizes the value of applied research and interdisciplinary collaboration, Coley says.

Ultimately, Coley hopes his work will improve the research process for thousands of scientists—making all of their discoveries and advancements a little bit faster. "That can have a pretty sizeable impact."

—Catherine Caruso SM '16

This graphic illustrates molecules at bottom left going through a neural network model (center). The single compound at the top right represents the product that the model believes will be formed.

ILLUSTRATION: CONNOR COLEY
PHOTO: CAROLINE WERLANG

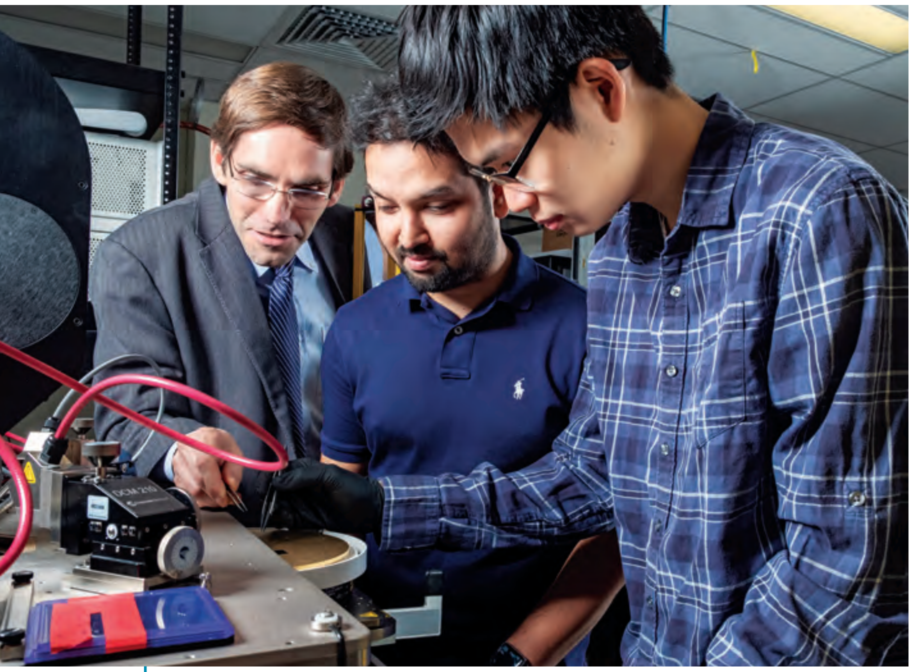
A Microcosm of Research

SuperUROP showcases breadth of computing applications

MIT undergraduates are using computing to tackle critical research questions, delving into fields as diverse as robotics, health care, and transportation through the Advanced Undergraduate Research Opportunities Program (SuperUROP).

A yearlong research experience supported by coursework, SuperUROP is an expanded version of MIT's Undergraduate Research Opportunities Program. SuperUROP was launched by the Department of Electrical Engineering and Computer Science and quickly expanded across the School of Engineering. Thanks to philanthropic support, it also now brings together projects in the School of Humanities, Arts, and Social Sciences with computer science.

"SuperUROP has evolved into a microcosm that showcases the research taking place around the Institute," says Ted Equi '81, SM '84, former SuperUROP industrial sponsor liaison. Equi, who is now the MIT Leaders for Global Operations director of academics, research, and career engagement, noted that 102 students enrolled in the advanced program this year. Here are project examples from this year's class.



Space Exploration / **Jaeyoung Jung '21,** Texas Instruments Undergraduate Research and Innovation Scholar

PROJECT TITLE: Gallium-Nitride Complementary MOS Microprocessor for High-Temperature Applications

ADVISORS: Tomás A. Palacios, professor, Department of Electrical Engineering and Computer Science (EECS), with PhD student Nadim Chowdhury SM '18

Silicon-based electronics have transformed life on Earth, but they are ill-suited to the demands of space. This project's goal is to equip computers for a trip to Venus, where surface temperatures can reach 471°C (880°F).

Semiconductors made with gallium nitride (GaN) rather than silicon can function at temperatures as high as 1,000°C. However, GaN circuits typically consume too much power to be used practically in microprocessors. Nadim Chowdhury, working with Tomás A. Palacios, has developed a new transistor that addresses this issue, work that could prove critical in deploying electronics in harsh environments.

An electrical engineering major, Jaeyoung Jung is working with Chowdhury and Palacios on the next step: designing the world's first energy-efficient GaN microprocessor. "This work will allow for sophisticated computing systems in spacecraft," says Jung, who uses industry-standard software for semiconductor device analysis and circuit design.

"If everything goes well, we expect Jaeyoung to start fabricating the GaN microprocessor at the new MIT.nano cleanroom facility in early 2020," says Palacios. The team hopes the microprocessor will be used to control a rover on a future NASA trip to Venus. "The SuperUROP program has allowed us to try a moon shot kind of project—in fact, a Venus-shot—and have an amazing MIT undergraduate student at the center of it."

Robotics / **Ashay Athalye '20,** Angle Undergraduate Research and Innovation Scholar

PROJECT TITLE: Sensor Fusion of Visual and Tactile Sensory Data for Object Localization and Robotic Manipulation

ADVISORS: Alberto Rodriguez, associate professor, Department of Mechanical Engineering (MechE), with MechE PhD student Maria Bauza SM '18

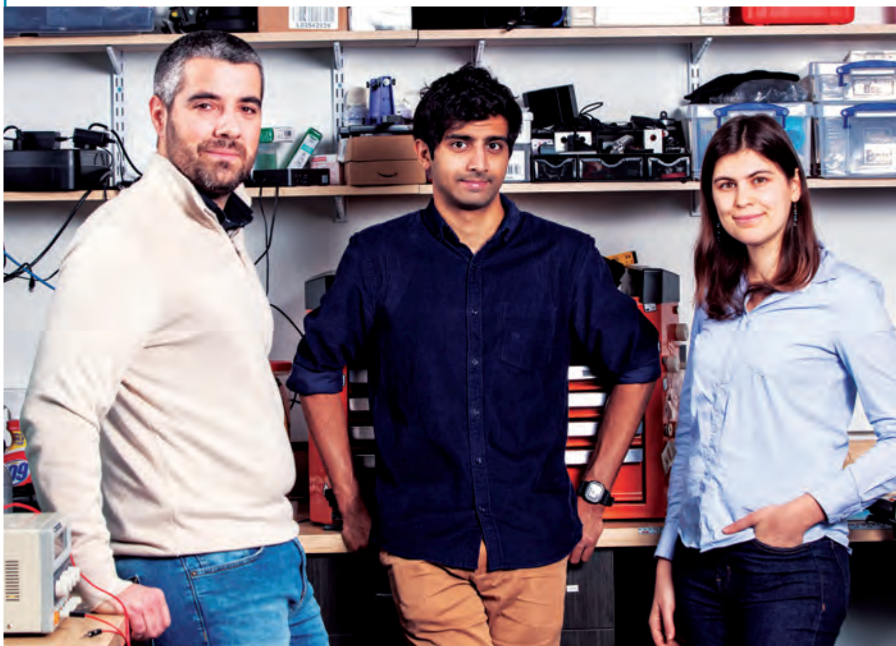
Like humans, robots need to perceive and understand their environment to manage tasks. Unlike humans, robots still can't easily and reliably track moving objects. Ashay Athalye's project combines visual and sensory data to assist a robotic arm in better estimating object location.

Currently, many robots employ deep-learning algorithms such as Deep Object Pose Estimation (DOPE), which uses images to estimate object position. However, DOPE doesn't consider information about where the object was previously or how it might be moving. Athalye, who is majoring in EECS with minors in mechanical engineering and economics, is endeavoring to incorporate such information by applying probabilistic filtering to the output of such algorithms, a method that has shown promise in preliminary testing.

"His work builds from state-of-the-art techniques based on deep learning to estimate the pose of objects under occlusions and fuse them with classic techniques for filtering that aim at providing smoother and temporally coherent object tracking," says advisor Alberto Rodriguez. "The particular approach involves adding a probabilistic interpretation to outputs of a deep neural network, which then can be used as measures of confidence to do robust object tracking."

Next, Athalye plans to apply similar filtering techniques to tactile data drawn from robot sensors. His goal is to effectively combine tactile and visual information to help robots with manipulation tasks.

"This project, which involves inference, machine learning, and control theory, has been a perfect way to apply what I've learned in my classes," Athalye says.



Transportation / Avital Vainberg '21, Undergraduate Research and Innovation Scholar

PROJECT TITLE: Visualizing Spatiotemporal-Activity Travel Patterns

ADVISORS: Joseph Ferreira Jr. '67, EE '70, SM '70, PhD '71, professor, Department of Urban Studies and Planning (DUSP) with DUSP PhD student Rounaq Basu MCP '19, SM '19

Location-tagged data are widely available but often underutilized by urban planners and policy makers. Avital Vainberg is working to put such data to better use by developing visualizations that are accessible to nontechnical audiences.

Vainberg, who is majoring in urban science and planning with computer science, and minoring in theater arts, is using travel survey data from Singapore to develop an interactive dashboard. "The goal is to inform planners and policy makers of where, when, and why people are traveling in order to encourage better decisions regarding land use, zoning, and transportation infrastructure."

Advisor Joseph Ferreira Jr. says, "Avital is focusing on a data-processing pipeline that isolates and parallelizes the computing-intensive image generation steps so that the activity patterns of subgroups can be visualized and compared on the fly from an interactive dashboard."

For example, Vainberg has created an animation that maps the activity patterns of Singapore's residents, revealing commuting habits and other trends. Her dashboard will enable users to filter the data by such criteria as demographics and time of day.

Ferreira says that these visualizations can reveal patterns that could otherwise be hard to detect, such as activity clusters that might signal a need for additional transportation.

"This project has simultaneously sharpened my coding and data science skills, pushed me to think critically of the world around me, and encouraged me to take on impactful projects," Vainberg says.

Computer Systems / Amir Farhat '20, Hewlett Foundation Undergraduate Research and Innovation Scholar

PROJECT TITLE: Understanding the Fundamentals of Reconfigurable Data Center Networks

ADVISOR: Manya Ghobadi, TIBCO Career Development Assistant Professor, Department of Electrical Engineering and Computer Science; Computer Science and Artificial Intelligence Laboratory

The explosion of data in every field from health care to business has spurred growing demand for big data analytics. This has led to increased use of big data server farms, where up to a million servers work together to tackle complex computations and run large applications such as web search engines.

A computer science and engineering major, Amir Farhat is endeavoring to make large-scale data centers more efficient by changing the physical topology of a wired data center network to increase its throughput. The goal is to develop a "smart" data center.

"By engineering the network to be reconfigurable to adapt to demand, we hope to increase the application performance in large-scale data centers," he says.

In traditional data center networks, operators decide in advance how much capacity to provide. Farhat is developing a simulation framework to experiment with alternative data center architectures and scheduling algorithms in the hopes of designing a reconfigurable data center.

"It might seem impossible to change the topology of a network without physically changing the cables," says advisor Manya Ghobadi. But she says optical networking, which encodes information in light waves, opens the door to new design options. Since optical waves can be redirected using mirrors, they are capable of quick changes: no rewiring required.

"This is a realm where the network is no longer a static entity but a dynamic structure of interconnections that may change depending on the workload," Ghobadi says, noting that Farhat is helping to lay the groundwork for the future. "This work promises to revolutionize the way networks are designed in practice, defined in textbooks, and taught in classrooms." —Kathryn M. O'Neill

Space Exploration: Tomás A. Palacios, Nadim Chowdhury, and Jaeyoung Jung
Robotics: Alberto Rodriguez, Ashay Athalye, and Maria Bauza
Transportation: Rounaq Basu, Avital Vainberg, and Joseph Ferreira Jr.
Computer Systems: Manya Ghobadi and Amir Farhat

PHOTOS: M. SCOTT BRAUER

COMPUTING

New Major Joins Computation, Cognition

Doron Hazan ’21 takes trailblazing path

When Doron Hazan ’21 was drafted into the Israeli Defense Forces (IDF) after high school, he had the opportunity to join the army’s intelligence unit. It was the obvious choice for the self-described “math and physics nerd” from Kiryat Shmona, a small town in Israel’s Hula Valley just south of the Lebanese border. But Hazan was not one to make obvious choices.

“All of my life I’ve been interested in human behavior,” says Hazan, a junior who is enrolled in one of MIT’s newest majors: computation and cognition, or Course 6-9. Launched in the fall of 2019, Course 6-9 is a joint curriculum offered by the Department of Electrical Engineering and Computer Science (EECS) and the Department of Brain and Cognitive Sciences (BCS). So far, 43 students have declared 6-9, and the departments expect the new major to eventually draw as many as 100 students each year.

“I could have done my military service surrounded by people similar to me,” Hazan recalls. “And serving in intelligence would have looked good on my resume. But I was more interested in learning about people and why they behave the way they do. So, I chose to join an infantry unit, where some of my fellow soldiers didn’t even know whether I had passed my high school matriculation exams.”

The new major seemed custom-made for Hazan. He’d followed a somewhat novel path to MIT—almost three years of service in the IDF, followed by two years of work and travel that took him to over a dozen countries in South America, Europe, and the Middle East. “There aren’t many people from Kiryat Shmona who even think about coming to MIT,” says Hazan, who first set foot on campus—and in the United States—a few days before the start of his first year at MIT in 2017. “When I told my mother I’d been accepted, she didn’t know what MIT was.”

Hazan had long known what MIT was. But during his first two years, he wasn’t entirely certain of his place. “I was taking computer science courses in EECS,” he recalls. “But I didn’t think I wanted to become a software engineer. And I was taking neuroscience courses in BCS. But I didn’t think I wanted to go into research. I don’t know if I could have articulated this at the time, but I was looking for a different path, a path that could help me start to address the big questions about life that have always intrigued me.”

With guidance from his advisor Michale Fee, the Glen V. and Phyllis F. Dorflinger Professor of Brain and Cognitive Sciences, Hazan has begun charting a new path through MIT in the new major. That path includes studies in psychology, statistics, engineering, programming, and neuroscience. Hazan’s goal, and the goal of faculty and students involved in Course 6-9, is to work toward a broader knowledge of the interactions between human and artificial intelligence, to understand neural circuits, and to design and build new interfaces between neurons and artificial neural hardware.

“I do feel that this major is somewhat of an experiment,” says Hazan. “But that’s one of the strengths of the program. And of MIT in general. It’s super flexible.”

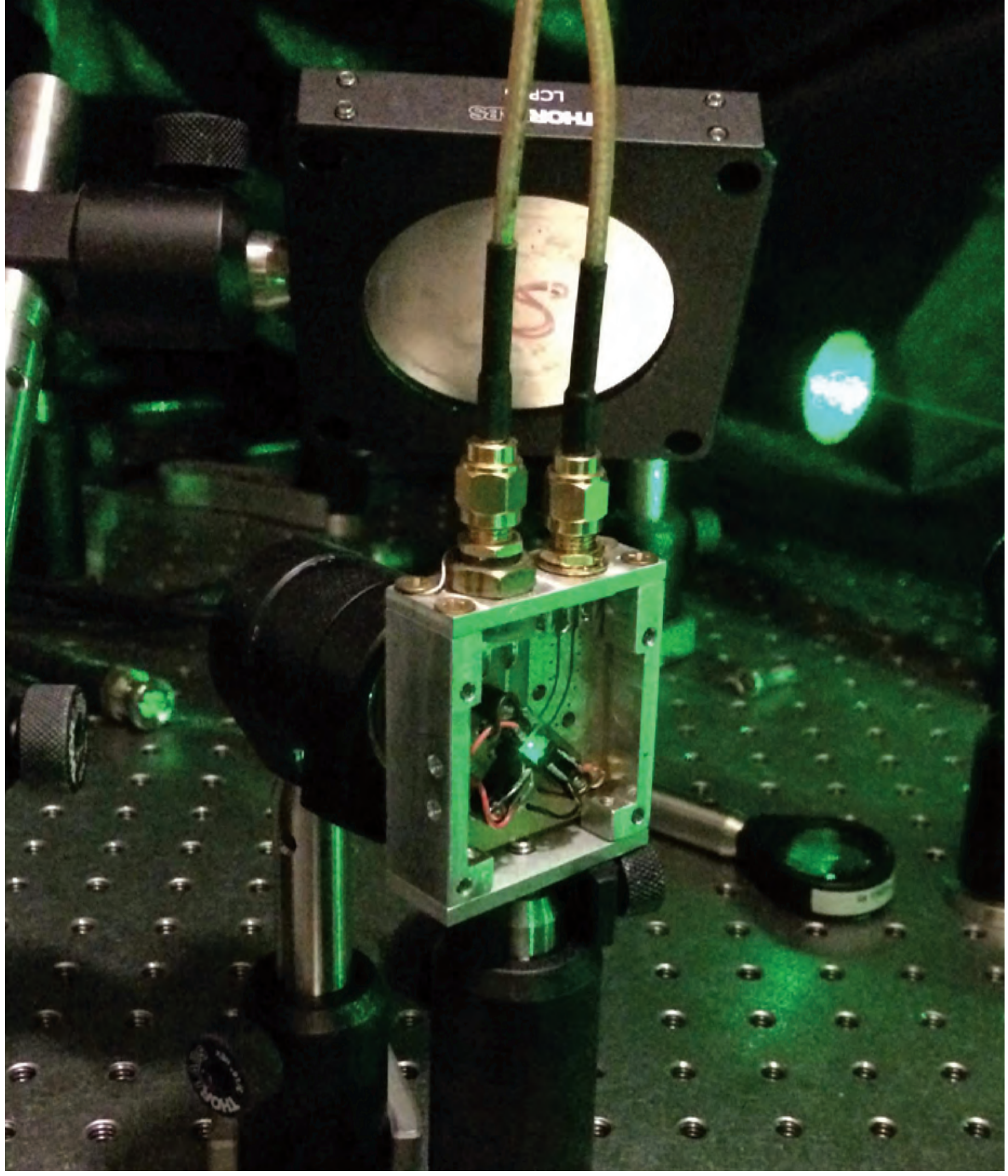
While Course 6-9 was a natural choice for Hazan, it is one he has had to explain. Several people even tried to discourage him from signing on. “They warned me that if I end up competing with a computer science major after graduation for a job in software, that the computer science major will get that job,” he says. “And that may even be true. But I’m not interested in learning how to be the best software engineer I can possibly be. I’m interested in knowing as many things as I possibly can.” —Ken Shulman

Doron Hazan ’21 is one of 43 students who have already joined the new major in computation and cognition.

PHOTO: KEN RICHARDSON

Quantum Leaps on the Horizon

Paola Cappellaro PhD ’06 advances next-generation computing



“Quantum” is one of those buzzwords that shows up in everything from science fiction to business branding. But quantum computing—or, more specifically, quantum information science and engineering—is a real, cutting-edge discipline focused on developing systems that will leave today’s fastest supercomputers in the dust.

In fact, it’s a whole ecosystem of technology based on quantum mechanics, a field of physics centered on how subatomic particles move and interact, according to Paola Cappellaro PhD ’06, an associate professor in the Department of Nuclear Science and Engineering (NSE). Cappellaro is at the forefront of MIT’s quantum computing research as leader of the Quantum Engineering Group in the Research Laboratory of Electronics.

“In my group, we work not only on quantum computing but also on associated technologies,” Cappellaro says. “The common thread is quantum information science, how to manipulate, encode, and exploit information using quantum devices.”

The technology is still in its infancy, but approaching computing from the vanguard of physics promises a sea change in how computers tackle huge mathematical challenges, such as breaking cryptographic codes, and simulate intricate systems, such as complex chemical reactions.

More memory and power

While conventional computers operate by processing bits of data consisting of zeros and ones, generally encoded in electronic form as on/off, quantum computing is based on principles that permit subatomic particles to be in different states simultaneously, enabling quantum bits, or “qubits,” to hold more information.

In theory, a quantum computer should outmatch even the most advanced supercomputer—but so far, no one has quite figured out the best way to build one. That’s because there are many possible ways to create the qubits of data, all involving different physical systems and types of hardware. Also, qubits are delicate and subject to what physicists call “decoherence” or the collapse of their fragile quantum state at the slightest vibration or change in temperature.

Another major challenge centers on addressing errors, which today’s computers handle through redundancy. “Instead of just encoding information in one bit, you can encode them in a certain number of bits and then you take a majority vote,” she says. This doesn’t work in the fuzzier realm of qubits, for a variety of reasons including that the disturbance caused by measurement (“wave-function collapse”) forbids checking the majority vote conditions.

Cappellaro’s Quantum Engineering Group is using electron and nuclear spins to address this challenge. Their approach centers on a type of defect found within the crystal lattice of diamond, called a nitrogen-vacancy or N-V center, that could be harnessed to create qubits.

Paola Cappellaro experiments with a diamond chip containing qubits, shown at the center of this apparatus, seeking ways to address errors in quantum computing.

PHOTO: COURTESY OF QUANTUM ENGINEERING GROUP

“We came up with a way of characterizing the noise in our system and then came up with an efficient way of protecting it from errors,” she says. “What we hope is that … we can actually have a practical error correction system for today’s intermediate-scale quantum devices.”

Collaborations at MIT

Quantum computers are expected to be able to tackle the biggest of big data challenges, but the specific applications may depend on which systems prove most practical. “We’re still in the stage where we’re trying to pick the best technology,” Cappellaro says.

Making such choices means exploring many different options, reflected in the broad range of researchers involved in quantum computing across the MIT School of Science and the MIT School of Engineering, as well as many groups at MIT Lincoln Laboratory. The MIT Stephen A. Schwarzman College of Computing is expected to better unite the Institute’s quantum computing efforts.

“We have a long tradition in quantum computation,” Cappellaro observes. “But the Schwarzman College could position MIT even better to play a larger role both in the United States and on the world stage. It’s definitely an opportunity to be seized.” —Mark Wolverton

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

A Responsible Path to Computing Advances

Ethical and social impacts drive efforts in education, research, policy

It's little wonder that David Kaiser and Julie Shah '04, SM '06, PhD '11 feel a sense of urgency in their new positions.

"Whether it's the large-scale collection of seemingly innocent data from individuals, or the use of artificial intelligence to create deep fakes in political disinformation campaigns, our norms, rules, and laws haven't caught up," says Kaiser, the Germeshausen Professor of the History of Science, and professor of physics. "We need to address many challenging questions head on, and right away."

Named associate deans of the MIT Stephen A. Schwarzman College of Computing (SCC) in September, Kaiser and Shah are spearheading an audacious initiative to embed the social and ethical dimensions of computing into the teaching, research, and public engagement tasks of the new college.

"In my work, I have a full appreciation for the opportunities and challenges of integrating these kinds of considerations into computing," says Shah, associate professor of aeronautics and astronautics, and a roboticist who designs systems in which humans and machines operate side by side. "There are areas where we could and should be doing much better."

Their initiative, the Social and Ethical Responsibilities of Computing (SERC), evolved during months of meetings with faculty from across the Institute. Catalyzed by these sessions, Shah and Kaiser are developing an approach that draws on the expertise of colleagues from a wide range of fields.

"There is a huge body of knowledge from the social sciences, humanities, and arts to help us frame problems in computing and develop systems for the betterment of mankind, and we need to start tapping into it," says Shah.

"We need new ideas and insights coming from multiple directions," says Kaiser. "Getting discussions and collaborations going across different disciplines, and with groups outside the Institute, is both a goal and a measure of our success."

Fostering ethical thinking

This commitment to cooperation and bridging courses of study is apparent in SERC projects already taking shape in the areas of teaching, research, and public engagement. For instance, collaborations between faculty teaching computing classes and those from fields across the humanities, arts, and social sciences will enable new emphases on global policy implications and social responsibility. The effective integration of such content will not be a trivial add-on.

"At the top of our list of learning objectives is the idea that technology alone can't solve many problems, and that our tools come with values incorporated in them," says Shah. "We need to complicate students' thinking, so as they code, experiment, and build systems, they are cognizant of ethics and impacts."

One way SERC will accomplish this goal, says Shah, is through courses co-taught by computing faculty and in such subjects as anthropology, philosophy, history, sociology, and management. Another way is by creating a series of short, curated case studies written by experts on such topics as algorithmic bias or automation and the future of work, which could be incorporated into a variety of classes and taught in collaboration with faculty from the humanities, arts, and social sciences.

"We want to make sure that there are substantial, unavoidable moments throughout undergraduate training that equip our students to analyze and make sense of hard problems involving social and ethical responsibility," says Kaiser. "To do this, they need to get tools and ideas about how different disciplines assess these challenges."

This deliberate effort to spark pedagogical alliances includes the arts, where MIT faculty have much to offer the SCC. "Amazing scholars here are thinking about what it means to be human and about our interactions with machines," says Kaiser, and they are already laying the groundwork for partnerships. "The School of Humanities, Arts, and Social Sciences recently approved a new concentration in computing and society that includes courses from nine different departments, including literature." SERC, say Kaiser and Shah, will build upon resources like these to integrate field-spanning classroom experiences into a coherent mission for the SCC.

New research dimensions

The vision for SERC also includes a robust research arm encompassing computing, allied fields, and areas of study that have not typically been included in collaborative projects.

"We want to spur discussions that should be happening but aren't," says Shah. "We plan to bring together an interdisciplinary community on a regular basis to look at the social, ethical, or policy implications of technologies, projects, and current events."

For example, SERC would provide opportunities for SCC faculty and graduate students to connect with faculty from the other fields of science and engineering as well as humanities, arts, and social sciences who could offer new perspectives on computing-related research problems. And, computing graduate students could engage in a yearlong clinic to tease out the ethical, social, and policy implications of their research—gaining insights they could then include in their dissertations.

"Our goal is to provide structure and opportunity for faculty and graduate students to discover intersections and build relationships with other disciplines," says Shah. "Then we

"We want to make sure that there are substantial, unavoidable moments throughout undergraduate training that equip our students to analyze and make sense of hard problems involving social and ethical responsibility," says Kaiser.

anticipate that those collaborations will generate new course content that flows back, enriching the MIT curriculum."

Informal discussions are already sparking such novel content, adds Kaiser, noting that one historian of finance and capitalism is looking forward to incorporating new materials about blockchain and cryptocurrency into his classes, which can be developed in partnership with computing specialists.

Wide impact

In the domain of public engagement, the SERC team hopes to make substantial impacts in both the near- and long-term.

One pathway, suggests Kaiser, will be uniting MIT's "world-class policy experts in computing, data, and society with anthropologists, historians, and philosophers" to produce white papers and proposals that influence government and industry.

But the SERC associate deans are also intrigued by another kind of public engagement. "Many people who are affected by our technologies are not at the table when these tools are being developed," says Shah. "So we think it's incredibly important to start building relationships and partnerships with local communities and organizations."

Kaiser cites a current, non-hypothetical case: Cambridge and Somerville are considering bans on facial recognition software within city limits, as a way of curbing surveillance of citizens and protecting privacy. "All-or-nothing solutions might not be the best way to go," he says. "Is there a way of getting lots of people in the room from MIT and these communities to discuss contentious issues?"

There's a precedent for this kind of dialogue. In the 1970s, Kaiser notes, university scientists, Cambridge city officials, and local community members debated the pros and cons of recombinant DNA research. The sometimes fraught discussions yielded a framework of rules and regulations that ultimately laid the groundwork for Kendall Square's thriving biotechnology industry, an economic driver for Cambridge and beyond.

It's early days still for SERC, and such public engagement will likely take some time to evolve. But as the two associate deans continue to build their ambitious agenda, they hope the vision they have been articulating will quickly take form on campus.

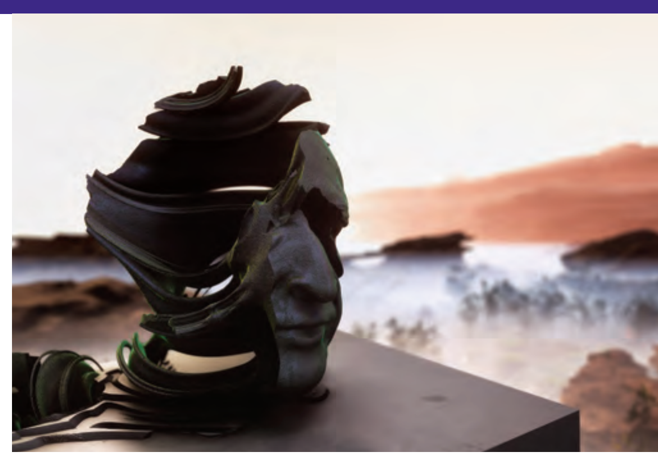
"A big win would be if we generate new collaborations for classrooms, research, and policy, get folks together to talk in new ways, and see new content percolate through the curriculum across a range of departments," says Kaiser. "That's a hard thing to do at a university."

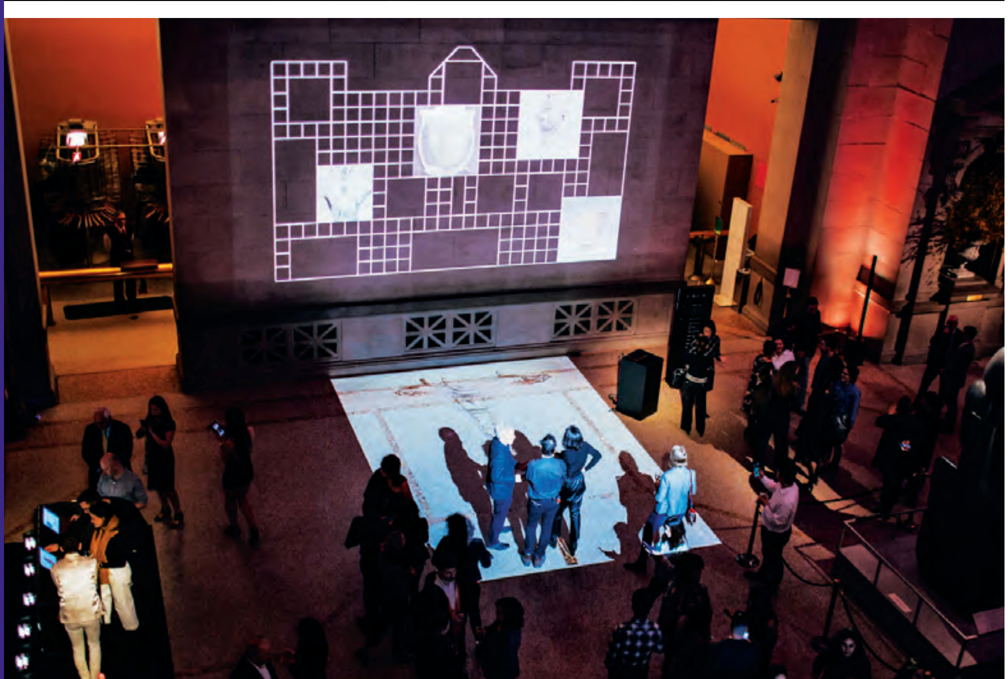
Says Shah, "If we can get students and faculty to reflect on the potential ethical, social, and policy implications of new technologies so they develop different habits of mind and action, and then move forward productively with good questions, that would be the ultimate success."

—Leda Zimmerman

(↗)
COMPUTING AND AI: HUMANISTIC PERSPECTIVES FROM MIT
bit.ly/MITHumanisticComputing

INTERSECTIONS WITH THE ARTS





Advanced computing has opened up new artistic possibilities that are being explored around the Institute. Examples include, clockwise from left: Gen Studio, a program spearheaded by Sarah Schwettmann, a PhD student in brain and cognitive sciences, that uses trained neural networks to explore the Metropolitan Museum of Art (image shows its unveiling in February 2019); Gatekeeper, an online game that models the sociological concepts of impression management and stigma developed by D. Fox Harrell, professor of digital media and artificial intelligence, and his Imagination, Computation, and Expression Laboratory; and *Chomsky vs. Chomsky: First Encounter*, a mixed reality piece that its creator—Sandra Rodriguez, a visiting scholar in Comparative Media Studies/Writing and a fellow at MIT Open Documentary Lab—calls "a conversation on AI, with AI, through AI."

IMAGES (CLOCKWISE FROM LEFT): VICTOR CASTRO; COURTESY OF D. FOX HARRELL; COURTESY OF THE NATIONAL FILM BOARD OF CANADA, SCHNELLEBUNTEBILDER, AND EYESTEELFILM

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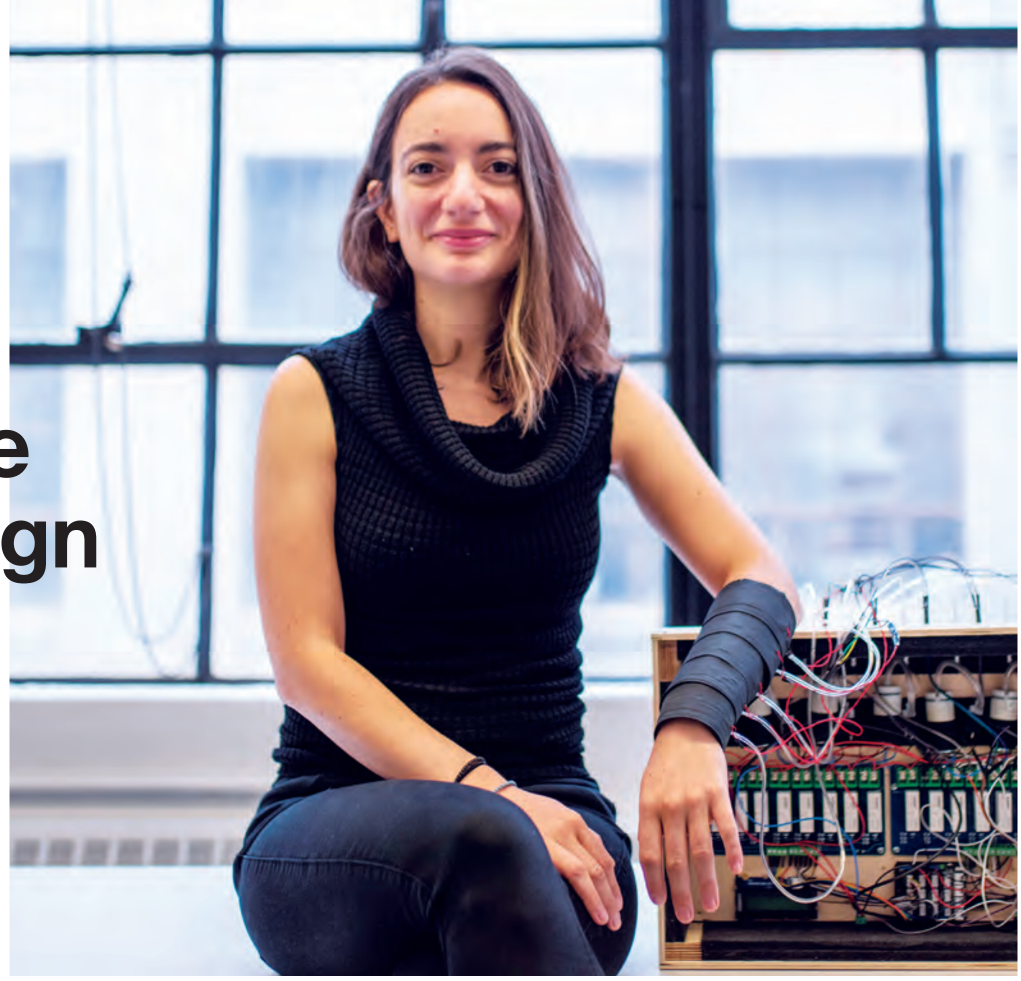
COMPUTING



Programmable Materials Design

Architecture grad student creates wearable tech for well-being

Is it possible for computational tools to help us understand the way our surroundings influence our emotional state? Athina Papadopoulou SM '14, a PhD candidate in the Department of Architecture's Design Computation Group, is exploring the intersection of design, computer science, materials, and psychology to see how wearable technology can help people experience spaces differently and regulate their emotional responses.

"Our psychology and behaviors are influenced by our environment," says Papadopoulou, noting that light, sound, and heat all affect how people feel, a key consideration for designers.

Combining computation and design offers new avenues for supporting mental and physical well-being, says Papadopoulou, who taught a studio class on inclusive design last spring. Students in the class created objects that communicated visual information through other senses to help the blind navigate spaces and experience art. Papadopoulou used programmable materials to help seeing students experience spaces through auditory and tactile senses.

The thread that ties together Papadopoulou's research projects is a desire to understand how the different senses contribute to our understanding of environments and experiences. Her master's thesis explored how the experience of a space changes if it's understood through touch, sound, or sight alone. Her PhD research focuses on what Papadopoulou calls "wearable environments"—how clothing can influence emotions and well-being.

Papadopoulou is developing a wearable sleeve to help people regulate their feelings and support biofeedback. The device, which inflates and applies rhythmic pressure, is programmed based on sensors that measure heart rate, electrical conductance of the skin, breathing rate, and other markers of the user's psychological state.

Athina Papadopoulou wearing the programmable affective sleeve she developed for her PhD research exploring materials as a modality for communicating emotions.

PHOTO: DIEGO PINOCHET

Influencing emotions

Research has shown that people who suffer from a range of mental health disorders have trouble processing, expressing, or even recognizing their own emotions. Papadopoulou's sleeve would help individuals get real-time insights into their physiological state as well as provide a way to influence emotions, especially to promote calmness, through warmth and pressure. "The basic idea is that by synchronizing environments with our bodies, we can enhance well-being," she says.

Papadopoulou is exploring how this tool can help both with self-awareness and with communicating emotional states. "There are already devices, or suits, that are designed for people with sensory processing disorders," explains Papadopoulou, a recipient of the Leon Hyzen Fellowship in Architecture. "They are things like a heavy blanket or a squeezable jacket, but they are not customized to the person's needs. I'm trying to make something that is customizable and can be controlled by the individual."

The project involves bringing together different disciplines as well as solving a number of challenges. First of all, it was difficult to find the right material for the inflatable sleeve, something that would both work with the sensors and provide the desired experience. "You have all these constraints from the materials," she says.

Choosing the right hardware was also challenging; it had to be able to work with the material but not be so loud that it would be distracting for the user.

Ultimately, Papadopoulou says, she was able to develop a working prototype and is currently conducting user studies. Papadopoulou is working under the guidance of Terry Knight, the William and Emma Rogers Professor of Design and Computation at MIT; Rosalind Picard SM '86, ScD '91, professor of media arts and sciences and director of the MIT Affective Computing research group; Skylar Tibbits SM '10, the Sherman Fairchild Career Development Associate Professor of Design Research and co-director and founder of the MIT Self-Assembly Lab; and Leah Somerville, a professor of psychology and director of the Affective Neuroscience and Development Laboratory at Harvard University. With the contributions of her advisors and colleagues, Papadopoulou created a user interface from scratch, managing a wireless communication system, handling networking concerns, and programming hardware to operate both the embedded sensors and the pressure controls for the sleeves.

Papadopoulou still hasn't found a good way to provide real-time sensor feedback, but she expects to eventually meet that challenge with some help from colleagues.

"We always see computation as a very multidisciplinary thing," Papadopoulou says. "My background is in architecture, other people come from the arts or engineering. Computer science nowadays is a big umbrella, it incorporates all these different fields." —Emily Omier

How Hype Proliferates

Sinan Aral examines social media's impact on health, economy, and democracy

It's been said "a lie can travel halfway around the world while the truth is still putting on its shoes"—a quote that's been (ironically) falsely attributed to Mark Twain, Winston Churchill, and Jonathan Swift. But none could have foreseen the power of social media to spread disinformation worldwide.

Sinan Aral PhD '07, the David Austin Professor of Management at the MIT Sloan School of Management, where he holds a joint appointment in the IT and Marketing groups, recently put the adage to the test by examining all the tweets sent in Twitter's first 10 years. Published in *Science* with colleagues Soroush Vosoughi '08, SM '10, PhD '15 (now an assistant professor at Dartmouth) and MIT professor of media arts Deb Roy SM '95, PhD '99 last year, the study found that false news stories on Twitter spread six times faster than true ones, and reached 100,000 people on average compared to 1,000.

"False stories diffused further, faster, deeper, and more broadly than the truth, in every category of information that we studied," says Aral. "Sometimes by an order of magnitude."

For two decades, Aral has studied "social contagion" between connected users online. His work will culminate with a new book, *The Hype Machine*, to be published by Crown this September, on the eve of the 2020 US election. The timing is fitting, given concerns over Russian interference in the last election, as well as the political disinformation trolls continue to propagate. Not all social contagion is bad, however. "This technology has the potential for tremendous promise and tremendous peril," says Aral. "It depends on how you use it."

Aral began examining how information spread online in 2001 as a managerial economics PhD student at MIT. He has been leading one of the primary research groups within the MIT Initiative on the Digital Economy (IDE) at MIT Sloan since its inception six years ago, and in July, will become the IDE's director. He examines how advertisers, governments, and nonprofits harness social media to influence online users. "Social media is really just a behavior change agent," he says. "If we point it toward problems we want to solve, we can do a lot of good in the world."

In an ongoing controlled study in South Africa, for example, Aral is examining the efficacy of a program to encourage HIV testing using phone messages from loved ones. In another study, he examined peer influence on exercise using a running app, finding people were more apt to run during inclement weather if they had a friend also running on the app that day.

Determining causation between false news and voting has been trickier. Even though 126 million Americans were exposed to Russian propaganda in 2016, researchers have been unable to tell how that affected the election, in large part due to Facebook and other companies' refusal to share data on individuals, something Aral calls the *transparency paradox*. "On one hand, they are facing tremendous pressure to show us how it all works," he says. "On the other, they are facing tremendous pressure to lock it all down to not violate people's privacy."

Techniques do exist, however, to anonymize data and fulfill both needs. In another *Science* article last year, Aral and Dean Eckles, the KDD Career Development Professor in Communications and Technology at MIT Sloan, argue that it is essential to employ them, both to determine the effects in the last election and to protect the next one. "Voting is a cornerstone of our democracy," Aral says. "If we are going to harden our democracy against that threat, we have to understand how it works." —Michael Blanding

"Social media is really just a behavior change agent," Aral says. "If we point it toward problems we want to solve, we can do a lot of good in the world."

Aral

PHOTO: COURTESY POPTECH INSTITUTE

AI Takes Research to the Next Level

The MIT Quest for Intelligence provides tools to tackle big data

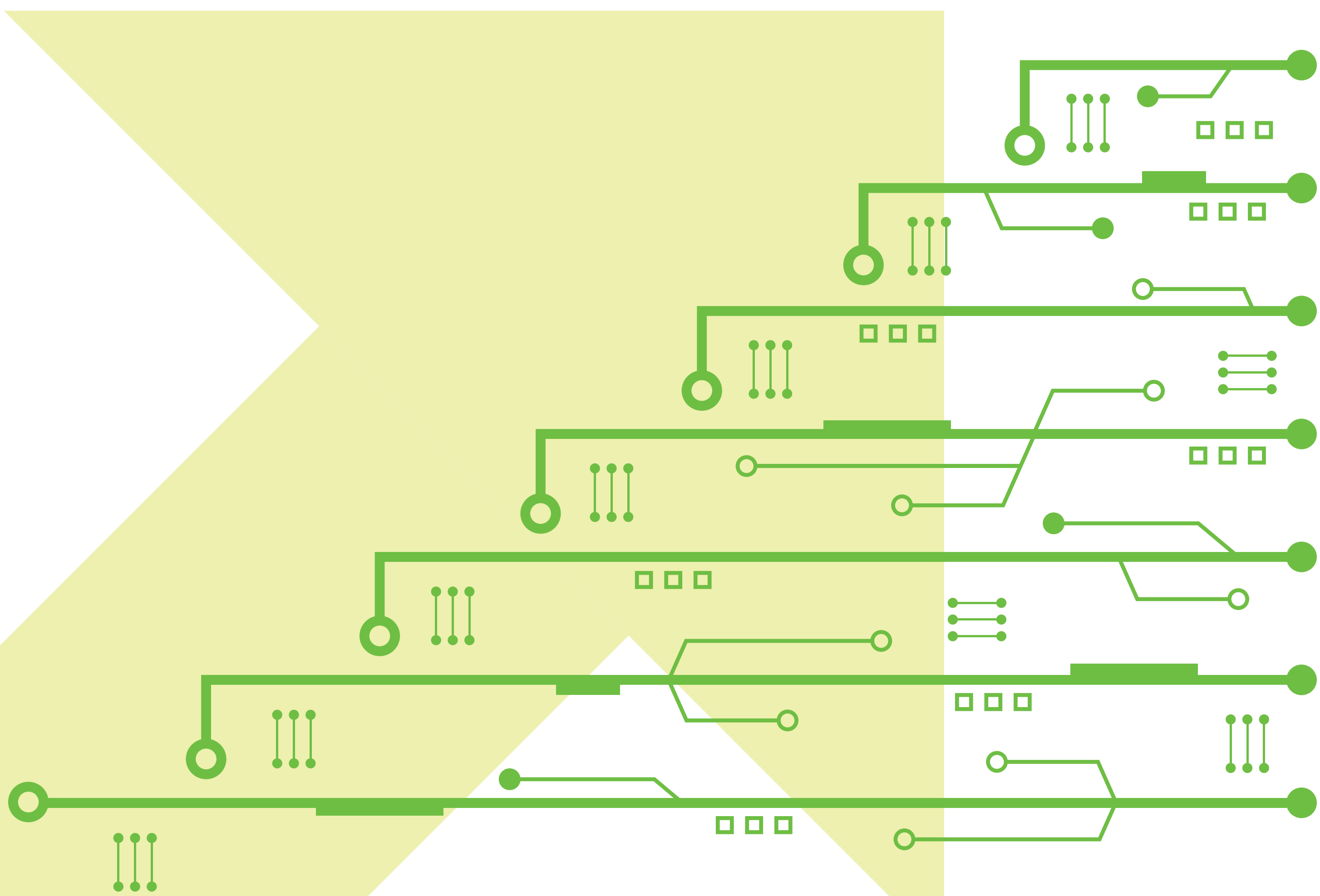
Back in 2016, when Reed Kopp began pursuing his PhD in the Department of Aeronautics and Astronautics (AeroAstro), he was staring down the barrel of years of mind-numbing data analysis. His project focused on designing and characterizing next-generation composite nanomaterials intended to make spacecraft and aircraft stronger, stiffer, and lighter. Since the materials are prone to failure due to hard-to-predict cracking, Kopp needed to study in detail where and why such cracking emerges.

He brought his samples to synchrotron light source facilities, where he bombarded them with X-rays to take intricate 3-D images of the interior of the materials as they experienced stress. The experiments yielded a total of 30 terabytes of microcomputed tomography (μCT) scan data that Kopp then sifted through by hand, image by image, to characterize the weak points and damage-propagation trends that caused the composite to fail.

“For a given scan,” says Kopp, “that could take about 15 hours of manual labor where we’re staring at a computer screen the entire time.” It’s time-consuming: the 2016 data set took well over a year to analyze. Kopp says it’s also impossible to be objective—repeated analyses will find different vulnerabilities in the same material.

This is exactly the kind of problem that would benefit from automation. And it is where the MIT Quest for Intelligence stepped into the picture.

A team of computer engineers within the Quest work with scholars across MIT to provide AI tools that accelerate research. Kopp and his supervisor, AeroAstro professor Brian Wardle SM ’95, PhD ’98, leapt at the



chance to partner with the Quest, initially providing 70,000 μCT images that had already been manually classified to train and validate an AI model. This model has since successfully located damage in scans 10 times the size of the training scans, saving hundreds of hours of manual labor.

Automating a task like this just wasn't a possibility before, making this approach revolutionary for the field of materials science. "To teach an AI model to think like we do, but do it faster and with larger amounts of data, is huge," says Kopp.

Smarter machines

Launched two years ago, the MIT Quest for Intelligence—now part of the MIT Stephen A. Schwarzman College of Computing—aims to bring the MIT community together to answer two monumental questions: How does human intelligence work, and how can human intelligence be reverse-engineered to build smarter machines that will benefit the world? Simply put, "if we know more about how we reason and how we learn to speak, translate, and make decisions," says Quest executive director Aude Oliva, principal research scientist at the MIT Computer Science and Artificial Intelligence Laboratory, "we could gain the insights needed to really advance AI."

ILLUSTRATION: NIKI HINKLE

Researchers from countless fields are generating tsunamis of data that cannot be processed and understood using traditional techniques. According to Oliva, these circumstances make it thrilling to find ways for AI to assist.

When the Quest agrees to take on a project, there's usually some function or nugget of code that humans just don't know how to articulate or write, according to Josh Joseph SM '08, PhD '14, chief intelligence architect for the Quest. "So we use the tools in machine learning to determine what that function should be," he says. By collaborating with researchers across an array of disciplines, Joseph and his team also get to discover whether AI techniques touted in the literature actually work in the real world or if they disintegrate on impact with, he explains, "all the grit and nuance and noise that can show up when you apply these tools to real-world problems."

Multidisciplinary applications

The Quest is currently supporting close to 100 research teams. Their projects span an extraordinary breadth of topics. Inside 500 Technology Square in Cambridge, for instance, postdoctoral researcher Amin Espah Borujeni works in the lab of Christopher Voigt, the Daniel I.C. Wang Professor of Advanced Biotechnology in the Department of Biological Engineering. He's reprogramming cells to do things that (to borrow a line from the old Tropicana Twister ad) "Mother Nature never intended"—but ones that would be rather useful to humans, such as treat disease and develop alternatives to fertilizers.

The challenge is that introducing genetic manipulations or designing genetic circuits can burden growth or even kill cells. Up until now, it hasn't been possible to predict such outcomes, let alone prevent them, because the thousands of genes inside each cell are part of a complex network of interactions that's hard to model without huge data sets. But this too-many-variables-insufficient-data problem is exactly what the Probabilistic Computing Project, located across the street in the Department of Brain and Cognitive Sciences, has been puzzling through for the last decade. The Quest brought Espah Borujeni and these researchers together.

The collaboration "is one of the first times we're working closely with a partner to solve an actual scientific problem," says Vikash Mansinghka '04, MNG '09, PhD '09, head of the Probabilistic Computing Project and a principal research scientist.

Espah Borujeni is excited by the hope that the model they're codeveloping will push forward the limits of synthetic biology. "I can see a real future there," he says.

There are other examples as well. The MIT Libraries have boxes stuffed with letters, memos, and documents that need to be reviewed, cataloged, and tagged by hand. Katherine Gallagher, an AI software engineer with the Quest, has worked with a team of undergraduate researchers to begin using machine learning to find an automated way to tackle this task. Their first prototype uses an image classifier to categorize documents and an image-to-text converter to extract information.

Gallagher is also collaborating with the Massachusetts General Hospital to identify viable livers for transplant from biopsy images. Of the 14,000 people each year that require such a transplant, only 8,000 receive one. An additional subset of fatty livers may in fact be viable, but they are often discarded at hospitals where physicians have not been trained to review the tissue samples properly. Using computer vision and machine learning to review these samples could help save people's lives, according to Gallagher.

The Quest is knitting people together across MIT, connecting them in a rapidly expanding network agnostic to academic boundaries. Of this interdisciplinary fabric Gallagher says, "I think there's nearly unbounded potential for new discoveries and solutions."

—Ari Daniel PhD '08

> "To teach an AI model to think like we do, but do it faster and with larger amounts of data, is huge," says Kopp.

Asking Questions of the Brain

McGovern researcher Ev Fedorenko probes links between thoughts, speech

Inside an MIT laboratory, a woman listens through headphones to passages from *Alice's Adventures in Wonderland* in Lithuanian, her native language. As the recording relays Alice's interactions with the Cheshire Cat and the Mad Hatter, a sophisticated imaging scanner tracks spikes of activity in the woman's brain.

Experiments like this help Ev Fedorenko PhD '07, investigator at the McGovern Institute for Brain Research and associate professor in the Department of Brain and Cognitive Sciences, explore a nagging puzzle: how do our brains perform the infinitely complex tasks of interpreting and generating language?

"Understanding how human minds perform high-level cognitive tasks is one of the greatest quests of all time," Fedorenko says.

"Understanding how human minds perform high-level cognitive tasks is one of the greatest quests of all time," she says. "Not only do we have incredibly sophisticated, abstract thoughts about how the world works, we can communicate those thoughts to one another. I find this feat incredible and want to understand the representations and computations that enable this."

The work could also lead to improved diagnosis and treatment of language disorders, building machines capable of understanding and generating language, and designing better educational programs for children with developmental language impairment or adults learning a second language.

Processing language

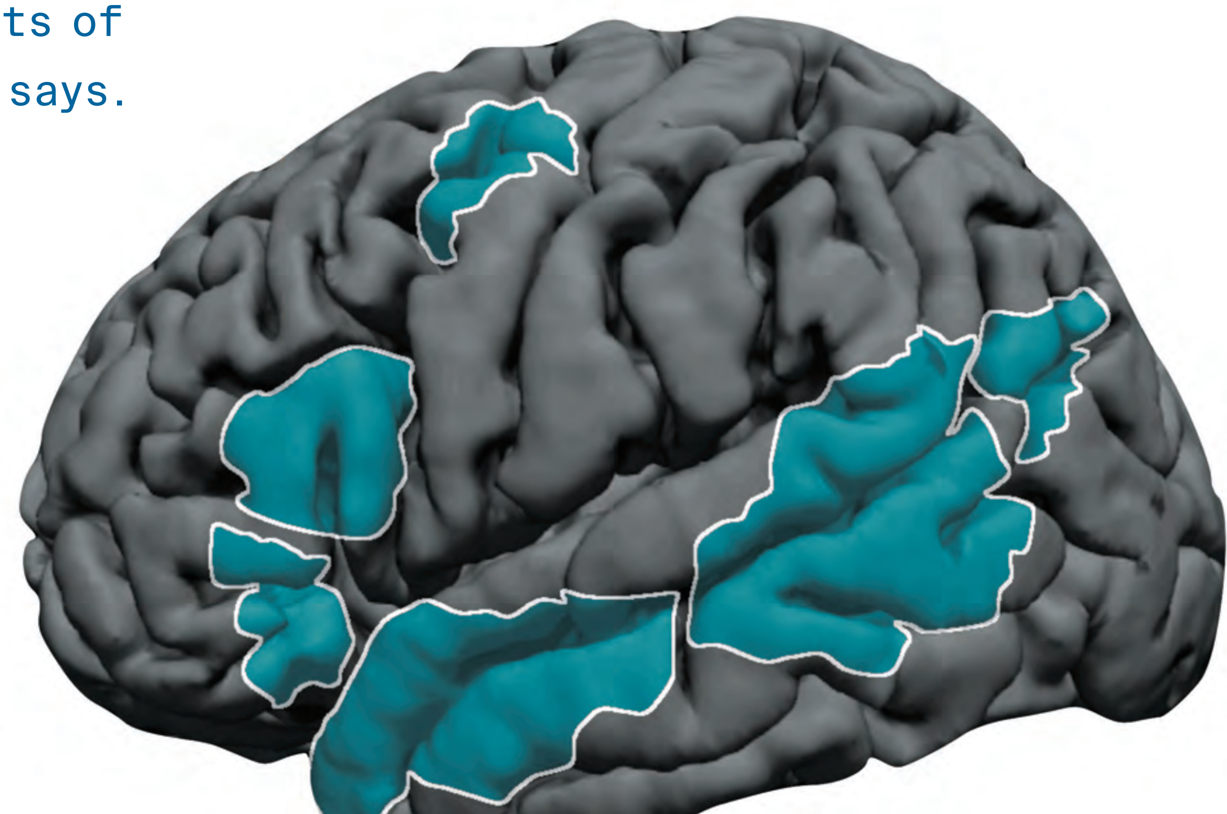
Researchers agree that language is processed primarily in the frontal and temporal lobes in the brain's left hemisphere. But the nature of the cognitive and neural mechanisms at work, and the potential contribution of other brain areas, is hotly debated.

While some argue that one focal area processes syntax, Fedorenko says there are empirical and computational reasons to reject that view. In 2016, Fedorenko's lab reported that syntax processing is distributed across the "entire ensemble" of brain regions that respond to high-level linguistic tasks.

Fedorenko uses techniques such as functional magnetic resonance imaging (fMRI), behavioral experiments, intracranial recordings, computational modeling, genotyping, and information gleaned from neurodevelopmental disorders to delve deeply into the interface between thoughts and utterances.

Amazingly, our brains seem to instinctively recognize certain sounds as human communication. "There's a part of our auditory cortex that responds to speech sounds and no other sounds at all," Fedorenko says. "Not to music, not to animal sounds, not to construction noises, just speech," whether the words are English, Tagalog, or Hindi. For these regions to get engaged, it doesn't have to be a language the listener can speak or understand. But the regions that get input from these speech-responsive areas—the ones that Fedorenko focuses on—care deeply about whether the speech is meaningful or not, showing little or no response to unfamiliar languages.

In fact, constructing complex meanings seems to drive these regions. Fedorenko has found that if you take a sentence and swap around the words so that it no longer reads like a logical sentence, the brain responds just as strongly as it does to well-formed sentences, a finding so surprising she was initially convinced it must be a mistake. It seems that as long as you can build meaning from nearby words, even if they don't



Ev Fedorenko has found that the language regions of the brain (shown in teal) are sensitive to both word meaning and sentence structure.

IMAGE: COURTESY OF EV FEDORENKO

McGovern Institute Turns 20

As a teenager in the 1950s, Patrick J. McGovern Jr. ’59 came across a book in a Philadelphia public library that would help define the course of his life. A reviewer called *Giant Brains, or Machines That Think*, by Edmund C. Berkeley, an “exquisitely clear and uncompromisingly evangelistic” treatise about the creation of the world’s first personal computer. Fifty years after reading it, McGovern cited the powerful influence of the book’s portrayal of computers as a means of “amplifying the human mind.”

In 2000, McGovern, founder and chairman of International Data Group, which published 200 information technology magazines, operated 460 websites, and produced 700 events in 79 countries, founded the McGovern Institute for Brain Research at MIT with his wife, tech entrepreneur Lore Harp McGovern.

Their $350 million founding commitment to the McGovern Institute remains one of the largest in the history of higher education philanthropy.

At the time of the institute’s founding, Lore and Pat said they believed neuroscience was poised to make major advances, including identifying the fundamental basis of brain disorders and launching potential new treatments for psychiatric and neurodegenerative diseases. They also hoped the institute would elucidate the scientific underpinnings of both creative achievement and conflict, ultimately transforming the world for the better. Pat passed away in 2014 at age 76, but Lore continues to remain involved with the institute as chairman and is now championing an addiction initiative involving multiple McGovern labs.

Now in its 20th year, the McGovern Institute comprises 22 faculty, three principal research scientists, and two McGovern fellows studying aspects of the brain ranging from molecular genetics to functional brain imaging. The institute has four research centers devoted to cutting-edge advances in imaging technology as well as the study of autism, psychiatric disorders, and intelligence.

Since its inception, the McGovern Institute has been producing a steady stream of discoveries about the inner workings of the brain in health and disease. “The momentum we have seen in brain research in recent years is truly astonishing,” says Lore. “I am thrilled to think of the insights and new treatment options for devastating diseases like depression and addiction that our labs will uncover over the next 20 years.” —Deborah Halber

The McGovern Institute is celebrating two decades of leading-edge brain research.

PHOTO: JUSTIN KNIGHT

occur in a grammatical pattern (“ate he apple an”), your language system works at full power. This makes sense, she says, given that we often get linguistic input that contains errors—when we talk to children, for instance, or non-native speakers.

No one, she believes, has done what she has set out to do: systematically investigate differences in the neural architecture of speakers of a broad sampling of the world’s 6,000-plus languages. The *Alice in Wonderland* project involves speakers of more than 40 languages (and counting), including Farsi, Serbo-Croatian, and Basque, listening to excerpts from the book translated into their native languages while the fMRI scanner records their brain activity. Fedorenko wants to know whether languages that use a strict word order, such as English or German, are processed differently from languages that have highly flexible word orders, such as Finnish or Russian.

So far, Fedorenko’s team is finding broad similarities across diverse languages. “If we can generalize the basic properties of the language architecture to, say, 50 languages that we’ve sampled across different language families, that gives credence to the idea that these properties are universal and determined by the general features of human language rather than idiosyncratic properties of a particular language,” she says.

Investigating multilingual speakers

Fedorenko is especially intrigued by polyglots. She’s found that speaking multiple languages engages the same set of core centers within the brain that help you speak and understand your native language. Polyglots’ language processing also seems to involve less, rather than more, blood flow, compared to monolingual individuals. It’s as though polyglots have flexed the brain’s language muscle so many times, they can use it more efficiently.

Multilingual herself, Fedorenko grew up in Volgograd, formerly Stalingrad, a city of more than a million that she recalls as mostly war memorials and drab apartment buildings on the bank of the beautiful Volga River.

With the dissolution of the Soviet Union in 1991, “things just fell apart,” she says. Her mother, a mechanical engineer with a law degree, and her father, a construction worker who performed multiple jobs for little or no pay, struggled to make ends meet. When her mother was ready to return to work after the birth of Fedorenko’s sister, there was no company to go back to.

Yet, starting at age seven, Fedorenko learned languages: English in school, plus French, German, Polish, and Spanish from locals that her mom enlisted to tutor her. “We were spending money on those kinds of things, even at times when we were borderline starving. My mom just saw that as a more important investment in my future"—a ticket out of Russia.

Inspired by Chomsky

It worked. Fedorenko spent her sophomore year of high school with a host family in Alabama and then enrolled at Harvard University in 1998 on a full scholarship. She studied psychology and linguistics. When she went on to pursue graduate studies in cognitive science and neuroscience at MIT, she came across a 2002 paper by MIT Institute Professor and emeritus professor of linguistics Noam Chomsky proposing that the defining feature of human language is structure-building, which may be shared with brain domains that process math and music.

"That seemed like a really cool idea," she says. "It just turned out to be wrong." Fedorenko wanted to evaluate Chomsky's hypothesis using the best scientific tools available, so she went on to develop a new fMRI approach to identify language-responsive areas in individual brains and then asked whether those areas also respond when we process structure in math and music. The answer was a resounding no.

Using her arsenal of tools, Fedorenko is now able to analyze the neural mechanisms of language-processing using dozens of manipulations and to relate neural data to state-of-the-art computational models of language processing such as those used by Google Translate. This allows her "to tackle important questions that have not yet been answered," she says. "Nobody has asked these kinds of questions, because people haven't had the tools to do it."

—Deborah Halber

"If we can generalize the basic properties of the language architecture to, say, 50 languages that we've sampled across different language families," Fedorenko says, "that gives credence to the idea that these properties are universal."

PHOTO: CAITLIN CUNNINGHAM

A Half-Century of Community Learning

Socializing, scholarship come together in Experimental Study Group

Maya Redden '23 arrived in Cambridge, Massachusetts, from a small town in Idaho. She wanted a smooth transition to college, especially one as large and rigorous as MIT.

She enrolled in the Experimental Study Group (ESG) on the advice of a friend who hailed the tight-knit ESG community and its small classes as an antidote to vast lectures. ESG, which marks its 50th anniversary this year, is a first-year program that combines community-building activities, such as weekend trips and themed Friday luncheons, with core academics. Enrollment is capped at 55 students each year.

"Most ESG classes have 12 students or fewer. It's really nice having that small class where you can take the time to stop and ask questions," Redden says, noting that the format fosters discussion, even in hard science classes.

Launched in 1969, the concept was revolutionary for MIT at the time, when many undergraduate requirements were taught in large lecture halls with as many as 500 students and one professor. ESG was founded by physicist George Valley Jr., Class of 1935, who created the Semi-Automatic Ground Environment air defense system, the impetus for MIT's Lincoln Laboratory. Valley wanted to bring small group learning to MIT's technical education.

"He was deeply concerned about the people MIT was not serving well," says ESG associate director Graham Ramsay. "We try to tear the curtain down between the siloed approach to education and social life, so that there's a sense that people commune together in very different ways. You walk by a classroom, and there's an awful lot of laughter, and people are very social and very much engaged."

ESG director Leigh Royden PhD '82, professor of geology and geophysics, identifies the cornerstones of ESG that have survived for 50 years. "ESG was founded on the principles of encouraging students to identify their academic passions, take responsibility for their own education to pursue those passions, peer teaching and learning, and community."

ESG has a dedicated suite that serves as a supportive village on an expansive campus, says program alumna Lydia Light '21.

"Every Friday, a few students cook for everybody. It's a supportive family. I know that ESG is a place that I can go to and feel at home," she says—to eat, meet friends, or chat with professors who thrive on personal contact with students.

"ESG is a celebration of diversity and experimentation, and I think that both diversity and experimentation are fundamental for the progress of community and humanity in general. Even though we're just a small group of people, I feel that we can make a difference," says physics lecturer Paola Rebusco.

And they do: James Rising '03 calls his ESG experience "transformative."

"MIT is a place where you're held to a very high standard. There are a lot of really smart people that, in other circumstances, you might feel in competition with," he says. "Instead, at ESG, we're all one big community helping each other."

Rising went on to become a research professor of climate economics at the London School of Economics. He says he was motivated by the experimental approach of Peter Dourmashkin '76, '78, PhD '84, an MIT senior lecturer in physics who "cared so much about helping us to understand deeply how physics worked, how to approach a problem, how to understand the essential elements of any question."

Students liked Dourmashkin so much, in fact, that they requested an extra seminar with him, and he said yes. "That's the kind of thing that happens at [ESG]. Now, as a professor, I'm drawing on those ideas of innovative project-based learning and helping students be in charge of their education," Rising says.

At ESG, students say, pushing boundaries, asking questions, and engaging deeply with the curriculum on a personal level lays the groundwork for the rest of their academic careers.

"The best decision that I made my freshman year was joining ESG. It had that big of an impact on my life here. I cannot recommend it more," Light says. —Kara Baskin

Left: Experimental Study Group students Rich Hilliard, Harry Bochner, and Henry Lieberman work together in 1972.

Right: Professor Leigh Royden, center, teaches physics to first-years (from left, Alexandra Nwigwe, Veronica Perdomo, and Maya Redden) in 2019.

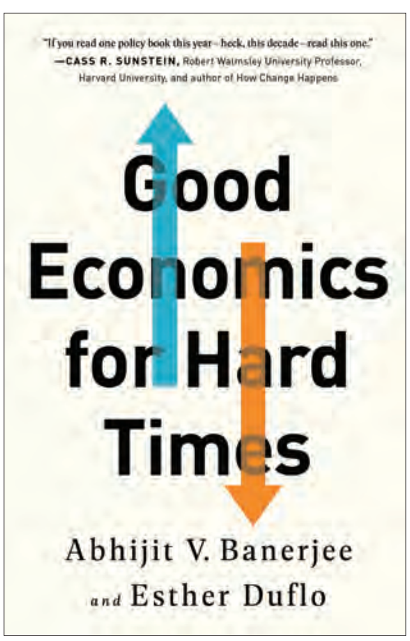
PHOTOS: COURTESY OF EXPERIMENTAL STUDY GROUP

Why Fight Poverty? Nobelists Explain

An excerpt from *Good Economics for Hard Times*

In October, MIT economists Esther Duflo PhD ’99 and Abhijit Banerjee were named co-winners, with Harvard University economist Michael Kremer, of the 2019 Nobel Prize in Economics for their groundbreaking research on combatting global poverty. The duo co-directs MIT’s Abdul Latif Jameel Poverty Action Lab. Duflo holds the Abdul Latif Jameel Professorship of Poverty Alleviation and Development Economics, and Banerjee is the Ford Foundation International Professor of Economics. Last fall, they released a new book, *Good Economics for Hard Times* (PublicAffairs, 2019), in which they explain how and why intelligent interventions can reap societal benefits.

[Creating successful policies to fight poverty] is patient work; spending money by itself does not necessarily deliver real education or good health. But the good news is that... [while we do not always know how to foster growth,] we know how to make progress here. One big advantage of focusing on clearly defined interventions is that these policies have measurable objectives and therefore can be directly evaluated. We can experiment with them, abandon the ones that do not work, and improve the ones with potential.



The recent history of malaria is a good example. Malaria is one of the biggest killers of small children and a disease preventable by avoiding mosquito bites. Since the 1980s, the number of malaria deaths had been rising every year. At the peak in 2004 there were 1.8 million deaths from malaria. Then in 2005 there was a dramatic turning point. Between 2005 and 2016, the number of deaths from malaria declined by 75 percent.

Many factors probably contributed to the decrease in the number of malaria deaths, but the widespread distribution of insecticide-treated bed nets almost surely played a key role. Overall, the benefits of nets are well established. In 2004, a review of the evidence from 22 carefully done randomized controlled trials [RCTs] found that, on average, 1,000 more nets distributed contributed to a reduction of 5.5 deaths per year. As we described in *Poor Economics* [PublicAffairs, 2011], however, there was a big debate at the time on whether nets should be sold to beneficiaries (at a subsidized price) or given for free. But an RCT by Pascaline Dupas and Jessica Cohen, replicated since then by several other studies, established that free nets are in fact used just as much as nets that are paid for, and free distribution achieves a much higher effective coverage than cost sharing.

Since *Poor Economics* was published in 2011, this evidence eventually convinced the key players that massive distribution was the most effective way to fight malaria. Between 2014 and 2016, a total of 582 million insecticide-treated mosquito nets were delivered globally. Of these, 505 million were delivered in sub-Saharan Africa, and 75 percent were distributed through mass distribution campaigns of free bed nets. The magazine *Nature* concluded that insecticide-treated net distributions averted 450 million malaria cases between 2000 and 2015.

The accumulation of evidence took some time, but it worked. Even the skeptics were convinced. Bill Easterly, who in 2011 was an outspoken critic of free bed net distribution, gracefully acknowledged in a tweet that his nemesis Jeff Sachs was more right than he was on this particular issue. The right policy choices were made, leading to tremendous progress against a terrible scourge.

The bottom line is that despite the best efforts of generations of economists, the deep mechanisms of persistent

“A clear focus on the well-being of the poorest offers the possibility of transforming millions of lives much more profoundly than we could by finding the recipe to increase growth.”

Esther Duflo PhD ’99 and Abhijit Banerjee shared the 2019 Nobel Prize in Economics.

PHOTO: BRYCE VICKMARK

economic growth remain elusive. No one knows if growth will pick up again in rich countries, or what to do to make it more likely. The good news is that we do have things to do in the meantime; there is a lot that both poor and rich countries could do to get rid of the most egregious sources of waste in their economies. While these things may not propel countries to permanently faster growth, they could dramatically improve the welfare of their citizens.

Investing in human capital

Moreover, while we do not know when the growth locomotive will start, if and when it does, the poor will be more likely to hop onto that train if they are in decent health, can read and write, and can think beyond their immediate circumstances. It may not be an accident that many of the winners of globalization were ex-communist countries that had invested heavily in the human capital of their populations in the communist years (China, Vietnam) or countries threatened with communism that had pursued similar policies for that reason (Taiwan, South Korea). The best bet, therefore, for a country like India is to attempt to do things that can make the quality of life better for its citizens with the resources it already has: improving education, health, and the functioning of the courts and the banks, and building better infrastructure (better roads and more livable cities, for example).

For the world of policy makers, this perspective suggests that a clear focus on the well-being of the poorest offers the possibility of transforming millions of lives much more profoundly than we could by finding the recipe to increase growth from 2 percent to 2.3 percent in the rich countries.... It may even be better for the world if we did not find that recipe.

J-PAL’s IDEA Taps Data for Impact

Every day, myriad organizations and governments digitally collect data about our finances, health, and behavior. Recognizing the potential of such vast quantities of data as a tool to fight poverty, researchers at the Abdul Latif Jameel Poverty Action Lab (J-PAL) at MIT recently launched the Innovations in Data and Experiments for Action Initiative (IDEA). IDEA was launched with startup support from the Alfred P. Sloan Foundation.

Since its founding in 2003, J-PAL has worked to reduce poverty by ensuring that policy is informed by scientific evidence. J-PAL affiliates typically run randomized evaluations by collecting primary data on the effectiveness of social programs. IDEA builds on the success of this strategy by partnering with governments, businesses, and nonprofits to utilize existing administrative data in experiments, and will use the results to scale up successful programs and strategically phase out those that aren’t achieving their desired goals.

“Using these data sets in creative and innovative ways to evaluate programs and therefore improve outcomes is a vital step toward making significant progress in the fight against poverty worldwide,“ says Iqbal Dhaliwal, J-PAL’s global executive director and a co-chair of IDEA. Dhaliwal notes that using existing data reduces research costs and frees up resources to serve many more people.

Already, J-PAL has worked effectively with administrative data from city and state governments in the United States and abroad. In Philadelphia, J-PAL-affiliated researchers used municipal data to track the impacts of a summer jobs program on crime, employment, and educational outcomes in low-income neighborhoods. In Rio de Janeiro, data on crime, police presence, and environmental factors informed an improved system for effective police response, helping to make communities safer.

To keep this momentum going, IDEA is planning for a conference that brings together researchers, data providers, and practitioners for collaborative discussions, presentations on IDEA’s ongoing work, and to kick off creating a handbook on best practices for using administrative data for research and evidence-based policy. IDEA is also exploring opportunities for collaboration with various other centers at MIT that are interested in working with big data, artificial intelligence, and machine learning, including the MIT Stephen A. Schwarzman College of Computing. —Christine Thielman

Open for Innovation

2020 marks the unveiling of two new MIT buildings in Kendall Square

Two of Kendall Square's newest and most prominent buildings will open in 2020, marking the first official building openings in MIT's Kendall Square Initiative. The structures, E37 and E38, will house the MIT Admissions Office, a more extensive innovation network, and hundreds of MIT graduate students and their families.

Both buildings are centrally located next to the inbound MBTA Red Line station, which draws thousands of commuters each day. Frequently referred to as "the most innovative square mile in America," Kendall Square is evolving in multiple ways. New retail spaces, including a grocery store that opened in 2019, and housing aim to make the square more livable as a destination beyond work. The opening of E37 and E38 marks a significant milestone for MIT, which has been playing a central role in the area's development.

E38: MIT Admissions, the MIT Forum, and the Innovation and Entrepreneurship Hub

"Welcoming visitors in the heart of Kendall Square will allow us to display the incredible vibrancy of MIT," says Stuart Schmill '86, dean of admissions and student financial services. The modernized MIT Admissions Office in E38 will be central to that effort as the new face of the Institute for more than 40,000 admissions visitors annually. Additionally, E38 will house the new 200-seat MIT Forum, a flexible event space that will serve the admissions office, other groups across MIT, and the broader Cambridge community—providing much-needed convening space on the east side of campus. It will also include retail spaces on the first floor that are separate from MIT and open to the public.

Schmill stresses that relocating the admissions office from Massachusetts Avenue to Kendall Square not only strengthens MIT's visibility but also highlights the critical connection the Institute has with the innovative high-tech enterprises that now flourish within the square. "With our new front door in Kendall Square, visitors will really get a feel for our focus on the future," he says. "But perhaps most importantly, this new location will allow us to more effectively showcase MIT's values and community."

The top-five floors of E38 will house the MIT Innovation and Entrepreneurship Hub (I&E Hub), an anchor for the campus-wide ecosystem that moves ideas to marketplaces. The I&E Hub will create spaces for students, researchers, and staff to gather, train, work, and build prototypes. "With the I&E Hub, we have a great opportunity to push MIT's innovation programming to the forefront," says Gene

The view down Main Street showcases the transformation of Kendall Square. Building E37, a new 29-story graduate residence, is at center.

MIT's dean of admissions says, "Welcoming visitors in the heart of Kendall Square will allow us to display the vibrancy of MIT."

Keselman MBA '17, executive director of the MIT Innovation Initiative. "We're also looking forward to hosting new activities that bring students, alumni, and professionals together as well as programs around diversity and inclusion."

The MIT Innovation Initiative will call the new I&E Hub home, as will cornerstones of the MIT innovation landscape such as the MIT Deshpande Center, MIT Venture Mentoring Services, MIT Sandbox, and the Legatum Center for Development and Entrepreneurship at MIT. MIT Proto Ventures, an ambitious effort launched by the MIT Innovation Initiative in 2019, will make dynamic use of the new space in its mission to bring domain experts to campus, exploring transformational technologies and pursuing business opportunities with members of the community. Three key sustainability-focused groups will also move to the facility: the MIT Environmental Solutions Initiative, the Abdul Latif Jameel Water and Food Systems Lab, and the MIT Office of Sustainability.

Keselman points out that the hub's location will influence the perception of innovation as a core value of MIT and a catalyst for groundbreaking work. "Many people have an idea that gathering spaces are going virtual, but I think the opposite is true," he says. "To have a physical place where everything comes together multiplies the strength and potential of everything that happens inside of it. That's the most exciting thing about the I&E Hub to me: seeing what happens when you put MIT's innovation programming together."

E37: Graduate residence and childcare center

With nearly 7,000 graduate students enrolled, MIT has seen an increasing need for housing both individual students and those with families. The fall 2020 semester will mark the first wave of graduate residents in new MIT housing in Kendall Square. The 29-story graduate residence will not only embed graduate students more fully in the Cambridge innovation landscape but place them in close proximity to their MIT labs and classrooms.

"MIT graduate students come from all over the world to conduct their research here, and it is critical that the Institute provide an array of housing options for them," says Cynthia Barnhart SM '85, PhD '88, MIT chancellor. "Building graduate housing in the heart of Kendall Square, where education and industry unite to form one of the most innovative districts in the country, will enhance MIT students' experience and add to the vitality of the area."

The new residence for graduate students and their families will have approximately 450 living units, including studios, one-bedroom, and two-bedroom units. The building will also house a new childcare center, providing the MIT community with programs for both toddlers and preschoolers. The center will include a dedicated drop-off area, classrooms, a gross-motor-skills playroom, an art room, and an outdoor play space.

Looking ahead

In the coming years, two more vibrant spaces will open at the same east campus "gateway to MIT": the MIT Museum and the Kendall Square Open Spaces. While the MIT Museum is still operating in its longtime home at 265 Massachusetts Avenue, it will move in early 2022 to occupy its first purpose-designed facility. The new museum will feature galleries, classrooms, hands-on activity spaces, and public meeting areas—all of which will highlight MIT's impact for a broad audience.

The two-acre Open Spaces will incorporate outdoor seating areas, green space, a stage, and a lawn for film screenings. These open spaces are designed to enhance the streetscape while featuring dynamic programming by MIT that is welcoming to all.

"Every element of the Kendall Square Initiative promises to benefit the MIT community as well as the area's innovation ecosystem," says Martin Schmidt SM '83, PhD '88, MIT provost and the Ray and Maria Stata Professor of Electrical Engineering and Computer Science. "The opening of E37 and E38 is just the beginning. We are looking forward to a future where Kendall Square engages, educates, and informs, and advances our work to make a better world." —Joelle Carson

Above, the new MIT Admissions Office is taking shape inside Building E38.

TAKE A VIRTUAL TOUR OF KENDALL SQUARE
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PHOTOS: ERIC KEEZER

KOW ’04 AND JOSIE ATTA-MENSAH

Helping MITES Reach More Students

Attending MIT’s Minority Introduction to Engineering and Science (MITES) program was an inflection point for Kow Atta-Mensah ’04, now a managing director at Morgan Stanley in New York. Under the umbrella of the MIT Office of Engineering Outreach Programs (OEOP) in the MIT School of Engineering, MITES brings rising high school seniors with exceptional academic records to campus free of charge for six weeks of rigorous coursework.

Kow was born in Ghana and moved to California with his parents when he was five, growing up as one of the few people of color in his community. At MITES, he was surrounded—for the first time—by people who not only looked like him but were “as smart or smarter” than he was. Kow describes the experience as empowering. “It was the first time in my life I felt I wasn’t the only one of something,” he says. “It changed my entire perspective.”

Successfully completing MITES gave Kow a “tailwind” through his last year of high school. He challenged himself to work even harder, taking on additional advanced placement classes because there was “nothing they could throw at me that would be harder than what I just did.” The MITES experience, which centers on supporting success in science and engineering, also solidified Kow’s desire to attend MIT.

Kow arrived on campus as a first-year student in the fall of 2000 along with some friends he made at MITES, but he says that without sponsorship from OEOP donors, that might never have happened.

In recognition of his life-changing experience, Kow and his spouse, Josie Atta-Mensah, recently created a significant endowment at MIT. The Kow and Josie Atta-Mensah Fund supports the OEOP with the goal of growing MITES and expanding opportunities for future students.

Kow went on to graduate from MIT with a degree in computer science and engineering, but a call from a friend pivoted his career in an unexpected direction. The friend was looking for a software engineer for his finance company, and Kow was intrigued by the firm’s cutting-edge work in artificial intelligence. He signed on and quickly became immersed in finance. He also discovered he was naturally gifted with financial derivatives. Two years later, he was recruited by Morgan Stanley for a position in an energy risk management structuring group, which he now leads. “I wasn’t planning this career, it just happened organically,” he says.

The couple’s success has enabled them to give back to causes they’re passionate about. They support organizations focused on helping underserved women with young children and on expanding educational opportunities for children living in poverty. While Kow had given small gifts to MIT over the years, Josie encouraged him to consider a larger gift so that MITES could impact other students’ lives as it had his.

“MITES is a telescope focusing on these bright shining stars who run the risk of going unnoticed,” says Josie, who was a director at Ralph Lauren and is now home full time with the couple’s young daughter. “The program does a beautiful job nurturing their potential and providing a springboard for their future.”

Part of the impact of the Atta-Mensahs’ gift was immediate. When Kow attended the MITES 2019 Symposium Luncheon in July, he was introduced to a young woman who told him she had received a rejection letter from MITES. Then, a few weeks later, she got a call from the program saying they had received the Atta-Mensahs’ gift and there was now space for her.

“Hearing that was instant acknowledgement that we were making a difference,” says Kow. “[The gift] is expanding the program and helping to reach more people, and that is amazing.” —Katy Downey

PHOTOS: DANA MAXSON

ROGER ALTMAN

Economics Department Hailed as "Rare Jewel"

Roger Altman has a long history of working with top economists, from serving in the US Department of the Treasury to his role as cofounder and chairman of the investment banking advisory firm Evercore. Many of the economists he praises most highly, however, are at MIT.

"The MIT economics department is a rare jewel," says Altman, who also cofounded and serves on the advisory board of The Hamilton Project, an economic policy initiative at the Brookings Institution. "Most years it's ranked number one in the country, yet it exists in the middle of a leading science and engineering school. This is an extraordinary accomplishment, and I'm quite interested in contributing to the preservation of that record at MIT."

To that end, Altman chairs the Department of Economics Visiting Committee, which convenes distinguished scholars, graduates, and members of the MIT Corporation to advise the department. "Roger is an invaluable partner in advancing our mission to lead in both economics research and education," says Department of Economics head Nancy Rose PhD '85, the Charles P. Kindleberger Professor of Applied Economics. "He is a great sounding board on many of our most pressing challenges," she adds, "and rolls up his sleeves to help work on them." Rose is appreciative of Altman's enthusiasm for one of the department's top priorities, need-blind admissions for its doctoral program, and grateful that he made a major gift to support expendable graduate fellowships: "His gift has had an immediate impact on what we're able to do."

Altman's support for MIT extends far beyond one department, however. He made a major gift to MIT's Task Force on Work of the Future, established in 2017 to study the evolution of jobs in the age of technological advancement, and chairs its advisory board. He gave his first gift to MIT in 2016, endowing a scholarship that has already provided financial support for five undergraduates.

A native of Boston, Altman is pleased to be of service to the Institute. "Growing up, I always admired MIT. I think everyone does," he says. "Much of MIT's support comes from non-alumni like me, often because they're trying to further an area of research that's personally interesting to them. MIT is the leader in so many areas."

Altman served as assistant secretary of the treasury during the Carter administration and as deputy secretary of the treasury in the Clinton administration. Today, he is a Life Member of the MIT Corporation, the Institute's governing body.

"It's been a richly rewarding experience," he says of his Corporation service. "In addition to attending Corporation and committee meetings, I try to spend regular time with faculty members. Those interactions represent a very steep learning curve for me! Although I did not concentrate in science as a student, I've always had a strong interest in it. My involvement with MIT gives me the opportunity to do many interesting things at once."

When possible, Altman enjoys spending time with students as well. "MIT students represent an extraordinary collection of talent and motivation," he remarks. "Every time I'm on the campus, I'm awed by students that I interact with even briefly, and I've never been exposed to a more impressive student body anywhere." Altman hopes that the scholarship fund he created "will bring students to MIT who wouldn't otherwise be able to attend and also increase the diversity of the Institute. That's important to me."

These days, Altman says he is particularly enthusiastic about the work of the Abdul Latif Jameel Poverty Action Lab. Cofounded by 2019 Nobel Prize winners and MIT economists Esther Duflo PhD '99, the Abdul Latif Jameel Professor of Poverty Alleviation and Development Economics, and Abhijit Banerjee, the Ford Foundation International Professor of Economics, the lab has helped transform antipoverty research and relief efforts (see an excerpt from their latest book on page 32). "I have a long-standing, serious interest in public policy as it intersects with economics," he says. "MIT economics and the Poverty Action Lab represent many exciting opportunities for positive impact on public policy." —Christine Thielman

Better World Events Outline Vision for Future

The MIT Campaign for a Better World international tour continues (19 cities and counting!), with MIT alumni and friends gathering in cities around the world to hear from Institute leaders, faculty, students, and alumni about how they are working to make the future brighter.

TOWARD A SUSTAINABLE FUTURE

Minneapolis

Thursday, October 29, 2020
Hyatt Regency Minneapolis

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Winter 2021
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THE MIT CAMPAIGN FOR A BETTER WORLD

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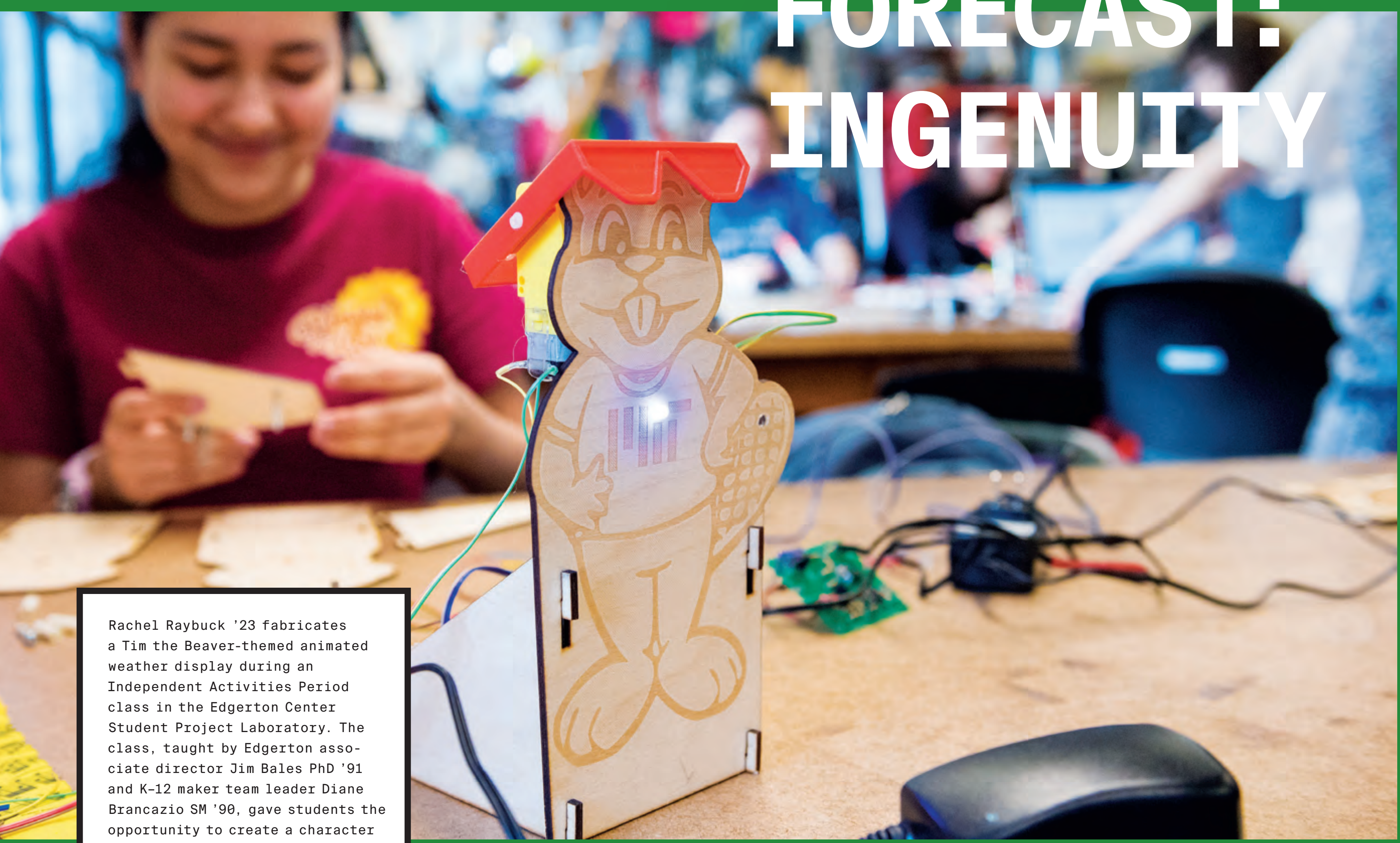
FORECAST: INGENUITY



Rachel Raybuck '23 fabricates a Tim the Beaver-themed animated weather display during an Independent Activities Period class in the Edgerton Center Student Project Laboratory. The class, taught by Edgerton associate director Jim Bales PhD '91 and K-12 maker team leader Diane Brancazio SM '90, gave students the opportunity to create a character with a laser cutter and 3-D printer, and to use analog circuitry to detect light and temperature levels with electronic sensors, as well as control LEDs and gear motors.

PHOTO: SARAH BASTILLE

CAMPAIGN FOR A BETTER WORLD