

## Dean, School of Science

### Overview

Astrophysicist Nergis Mavalvala was named the new dean of the [MIT School of Science](#) effective September 1, 2020. She succeeded Michael Sipser, who returned to the faculty as the Donner Professor of Mathematics after six years of service. Mavalvala, the Curtis and Kathleen Marble Professor of Astrophysics, is renowned for her pioneering work in gravitational-wave detection, which she conducts as a leading member of the Laser Interferometer Gravitational-Wave Observatory at MIT. She has received numerous awards and honors for her research and teaching and previously had been the associate head of the Department of Physics. Mavalvala is the first woman to serve as dean in the School of Science.

On the national stage, President Joseph R. Biden selected two MIT faculty leaders—Broad Institute of MIT and Harvard director Eric Lander and MIT vice president for research and E. A. Griswold Professor of Geophysics Maria T. Zuber—for top science and technology posts in his administration. Lander was named presidential science advisor, and for the first time in history this position was elevated to the cabinet level. He was also named director of the White House Office of Science and Technology Policy, a position that required Senate confirmation. Zuber was named co-chair of the President’s Council of Advisors on Science and Technology, along with California Institute of Technology chemical engineer Frances Arnold. Zuber and Arnold are the first women to co-chair the council.

MIT scientists and engineers were well represented in the National Aeronautics and Space Administration (NASA) Mars 2020 mission and the launching of the Perseverance rover in July 2020 and its landing on the Red Planet in mid-February 2021. Perseverance carries a sophisticated system for selecting, coring, caching, and preserving rock and soil samples to bring back to Earth. Professor of Geobiology and member of the mission’s Project Science Group Tanja Bosak and Professor of Planetary Sciences Ben Weiss, both from the MIT Department of Earth, Atmospheric and Planetary Sciences (EAPS), are participating scientists on a 10-person return sample selection team. With expertise in biogeochemical and sedimentological processes in microbial systems and paleomagnetism and planetary geophysics, they are tasked with helping to identify promising samples on the Martian surface for signs of previous life.

In international science news, astrophysicist Andrea Ghez ’87, a professor of physics and astronomy at the University of California at Los Angeles, was awarded the 2020 Nobel Prize in Physics by the Royal Swedish Academy of Sciences. She shares half of the prize (with Reinhard Genzel) “for the discovery of a supermassive compact object at the center of our galaxy.”

Back in Cambridge, summer 2020 was spent in preparation for an academic year unlike any other at MIT. With the continued threat of Covid-19, MIT took significant measures to protect students, faculty, and staff by significantly reducing the on-campus population and ramping up remote learning and instruction.

In academic year 2021, community members within the MIT School of Science continued to produce research on the fundamental biology of the SARS-CoV-2 virus and develop rapid testing of potential vaccine treatments. Despite the ongoing constraints posed by the pandemic, the School of Science continued to lead in research concerning climate science and push forward with initiatives in diversity, equity, and inclusion (DEI) within the larger Institute framework of the updated climate and diversity action plans.

## **Initiatives and Programs**

### **Diversity, Equity, and Inclusion**

In the School of Science, the wider community engaged in actions to support the Black community including the June 2020 teach-ins and protests connected to the larger national day called #ShutDownSTEM. Science, technology, engineering, and mathematics (STEM) researchers, students, leaders, and support teams were encouraged to use the day to engage in the fight for equity, inclusion, diversity, and fair and equal treatment of marginalized communities.

At the beginning of July 2020, President L. Rafael Reif wrote to the Institute community with a commitment to addressing systemic racism at MIT. This message followed closely after actions that galvanized the current racial justice movement in the United States, including the death of many Black Americans and the public murder of George Floyd.

In September 2020, John Dozier, Institute community and equity officer, and Tim Jamison, associate provost and Robert R. Taylor Professor of Chemistry, announced the development of an MIT-wide DEI strategic action plan that provides both a baseline for measuring and assessing progress and a mechanism for accountability. Dozier, Jamison, and Maryanne Kirkbride, deputy Institute community and equity officer and executive administrator of MindHandHeart, released the first draft of the DEI plan in March 2021 with the three strategic priorities of composition, belonging, and achievement.

In close coordination with the Institute community and equity officer, the administration in the School of Science has outlined its DEI initiatives and programs in concert with these three priorities. In one of the most visible actions, Kuheli Dutt joined the school as the new assistant dean for DEI, one of six new assistant dean positions created across the Institute. Most recently, Dutt served as assistant director for academic affairs and diversity at Columbia University's Lamont-Doherty Earth Observatory, where she oversaw DEI efforts related to appointments and promotions, salary structures, mentoring, awards and recognition, governance, and the advancement of junior scientists.

These newly created positions were a result of the February 2020 recommendations of the MIT working groups charged with implementing the findings of the National Academies of Sciences, Engineering, and Medicine's report on sexual and gender harassment of women in academia. Together, the group's reports called for "a network of support, advocacy, and community-building expertise across campus to improve our community culture."

### **LEAPS Program**

In spring 2020, the School of Science helped launch courses for graduate students and postdocs as part of the LEAdership and Professional Strategies and Skills Program

(LEAPS). Developed and co-led by Anna Frebel, astrophysicist and professor of physics, and Angeliki Diane Rigos, physical chemist and director of MIT's Tata Center for Technology and Design, 8.S396 Sharpen Your Professional Strategies & Skills and 8.S397 Developing Your Leadership Competencies offer vital guidance for advancing careers in academia and industry. The course content includes training on understanding bias, developing ethical leadership skills, and championing and implementing change.

## Climate

In May 2021, President Reif, Vice President for Research Zuber, and others announced a new plan to address the accelerating crisis of climate change. Fast Forward: MIT's Climate Action Plan for the Decade outlines two tracks for combating climate change: using current tools to effect change and investing in and implementing new tools, methods, and policies.

At the core of the plan is the centrality of science. Since the 1970s, MIT faculty have pioneered efforts to understand the essential dynamics of global warming and its effects across land, atmosphere, oceans, and ice sheets. This research is the foundation of the Institute's strategy. With this new plan, MIT redoubles its bedrock commitment to expand humankind's knowledge of the forces disrupting the climate. MIT will increase its efforts to achieve a deeper understanding of these issues, to advocate for science as the compass for climate policies, and to press for public and private support for climate research.

In addition to public and governmental advocacy work, science faculty and administrators contributed many hours to internal communications on climate change through the Institute's Climate Symposia series. Faculty members including John Deutch, Department of Chemistry Institute Professor emeritus; Kerry Emanuel, Cecil and Ida Green Professor of Atmospheric Science in EAPS; Colette Heald, professor in the Department of Civil and Environmental Engineering and EAPS; Ernest J. Moniz, the Cecil and Ida Green Professor of Physics and Engineering Systems emeritus in the Department of Physics; and Zuber organized the symposia around topics in which MIT can make an immediate or lasting difference in the climate crisis.

In advance of the plan, MIT also announced the creation of a research effort called the Climate Grand Challenges to solicit proposals for funding research to tackle seemingly intractable issues concerning climate change. EAPS department head Robert van der Hilst and other members of the faculty review committee issued a call for proposals, and 28 teams were offered the chance to more fully develop white papers on their research proposals. The final proposals will be announced in fall 2021.

In addition, the Institute announced the creation of the MIT Climate and Sustainability Consortium (MCSC) as part of the Climate Action Plan. Just as the Climate Grand Challenges accelerate research on climate science and solutions, the consortium will accelerate the adoption of such solutions at scale and across industries. Professor of Chemistry Jeremiah Johnson and Associate Professor David McGee from EAPS both represent science's interests as part of the MCSC steering committee.

Overall, the school's efforts in climate science and sustainability research are in sync with central efforts to position MIT as a leader in this crucial moment for the planet.

## Education

MIT is exceptional among major research institutions for its dedication to undergraduate education. Unlike most leading schools of science, MIT places great emphasis on hiring and promoting young faculty members and using undergraduate teaching as an important criterion for promotion and tenure. It is not uncommon for Nobel Prize winners and others among our best researchers to teach first-year subjects. Committed to providing undergraduates with a strong science base for studies in their majors, the school and its departments participate in and support a variety of programs designed to create more active, student-centered learning environments inside the classroom.

The School of Science has continued to expand educational and training opportunities for graduate students, collaborating with other schools and centers within the Institute to create innovative graduate programs in fields in which MIT shows great strength. These programs exemplify the Institute-wide goal of reducing boundaries between disciplines and allow MIT to attract the most talented students in their respective fields. The programs—including biophysics, computational and system biology, microbiology, molecular and cellular neuroscience, and statistics and data science—integrate educational resources across participating departments, build connections among faculty with shared interests, and create an educational and research community for training students.

In fall 2020, the Department of Biology tapped two scientists with experience working on pandemics to develop the course 7.00 COVID-19, SARS-CoV-2 and the Pandemic. Whitehead Institute member and MIT professor Richard Young, who had been quick to organize Covid-19-related research efforts, and Facundo Batista, associate director of the Ragon Institute of MGH, MIT and Harvard and a resident expert on immunology and infectious disease, led the course with guest lecturers including Anthony Fauci, the longtime director of the National Institute of Allergy and Infectious Disease. The course will run again in the fall semester of 2021.

## EdX

Krishna Rajagopal, the William A.M. Burden Professor of Physics, is dean for digital learning, with oversight of Residential Education, MITx, OpenCourseWare, and the Digital Learning Lab. Rajagopal oversaw a massive undertaking in spring 2020 to ensure that courses were moved online for remote learning, laying the foundation for remote instruction in the fall 2020 semester. Rajagopal will step down from his position as dean effective August 1, 2021.

In order to support MIT's goals to establish leadership in online education through our involvement with EdX and our own MITx initiative, School of Science departments continue to add to MITx curricula on EdX, massive open online courses (MOOCs), and OpenCourseWare.

In the fall 2020 semester, a new course was offered by J. C. Sheehan Professor of Chemistry Sylvia Ceyer, Professor of Chemistry Mei Hong, Digital Learning Lab fellow David Grimes, Alisa Krishtal, and Patti Christie. The course, 5.01x General Chemistry I: Atoms, Molecules, and Bonding, explores chemical structure and bonding from a quantum mechanical perspective and allows learners to build core skills in chemistry (e.g., drawing chemical structures and predicting molecular properties and reactivities) and gain fundamental knowledge for advanced courses.

A series of courses focused on cell biology were added to EdX: 7.06.1x Cell Biology: Transport, led by Professor of Biology Frank Solomon and Robert A. Swanson Career Development Professor Rebecca Lamason; 7.06.2x Cell Biology: Signaling, taught by Solomon and Professor of Biology Iain Cheeseman; and 7.06.3x Cell Biology: The Cytoskeleton and Cell Cycle, led by Cheeseman. Building on existing introductory biology and biochemistry MOOCs, this series elevates discussion of the subject matter to an experimental level, exploring how scientists apply various methods and techniques, interpret data, and design experiments.

In the spring 2021 semester, Kristin Bergmann, the D. Reid (1941) and Barbara J. Weedon Career Development Assistant Professor in EAPS, led 12.12.1x The History of Ancient Environments, Climate, and Life, examining Earth from roughly 2 billion years ago to 500 million years ago using rocks from around the world. An introduction to Earth history and geology, the course includes lectures, interviews, and virtual trips to various field sites, from Minnesota to Norway.

Finally, Matěj Peč, an assistant professor in EAPS, received an MITx Modules grant to facilitate 12.DTEx Deform the Earth! This virtual rock deformation lab, held residentially in summer 2020, will be offered as a MOOC next year.

The 2021 MITx Prize for Teaching and Learning in MOOCs, which honors excellence in creating MOOCs for MITx on EdX, was awarded to instructors of two courses including 15.480x The Science and Business of Biotechnology. This course was created by Professors Andrew Lo of the MIT Sloan School of Management and Harvey Lodish of the Department of Biology along with graduate students Zied Ben Chaouch (Department of Electrical Engineering and Computer Science [EECS]) and Kate Koch (Department of Biology) and EECS graduate Shomesh Chaudhuri '14, PhD '18.

Co-sponsored by MIT Open Learning and the Office of the Vice Chancellor, the Teaching with Digital Technology Awards are student-nominated awards presented to faculty members and instructors who have improved teaching and learning at MIT with digital technology. This year's awardees include Physics instructor Mohamed Abdelhafez '11; Laura Frawley, lecturer in Brain and Cognitive Sciences; and Mathematics lecturer Jeremy Orloff.

### **Education Awards**

This year, Kristin Bergmann; Catherine Drennan, a professor in the Departments of Biology and Chemistry; and Gigliola Staffilani, the Abby Rockefeller Mauzé Professor of Mathematics, received the MIT Office of Graduate Education's Committed to Caring Award for "dedicated advocacy and for connecting students with wider intellectual communities." Colette Heald and Professor of Biology Gene-Wei Li were also honored with the award "for crafting inclusive laboratory environments, as well as continually empowering their students." Finally, Kerri Cahoy, an associate professor of aeronautics and astronautics with a joint appointment in EAPS and a member of the MIT Kavli Institute for Astrophysics and Space Research, received the award for "compassion and staunch advocacy for graduate advisees."

The Office of the Vice Chancellor and the Registrar's Office announced the 2021 Margaret MacVicar Faculty Fellows, including Claude E. Shannon Professor of Mathematics Larry Guth and Professor of Biology and Biological Engineering Michael Yaffe. For nearly three decades, the MacVicar Faculty Fellows Program has recognized exemplary and sustained contributions to undergraduate education at MIT. The program was named after Margaret MacVicar, the Institute's first dean for undergraduate education and founder of the Undergraduate Research Opportunities Program.

## Research

School of Science researchers seek to answer fundamental questions about nature ranging from the microscopic—where a neuroscientist might isolate the electrical activity of a single neuron—to the telescopic—where an astrophysicist might scan hundreds of thousands of stars to find Earth-like planets in their orbits. The following is only a subset of the school's many research programs and publications.

## Covid-19

Basic scientific research conducted at MIT in the 1970s by Institute Professor Phillip Sharp and others laid the groundwork for the approval of the Food and Drug Administration's emergency use authorization of messenger RNA vaccines against Covid-19. Instead of delivering a virus or a viral protein, RNA vaccines deliver genetic information that allows the body's own cells to produce a viral protein. Synthetic mRNA that encodes a viral protein can borrow this machinery to produce many copies of the protein. These proteins stimulate the immune system to mount a response without posing any risk of infection.

Robert Langer, the David H. Koch Institute Professor at MIT, a member of the Koch Institute for Integrative Cancer Research, and one of the founders of Moderna, spent decades developing novel ways to deliver medicines, including therapeutic nucleic acids such as RNA and DNA. In the 1970s, he published the first study showing that it was possible to encapsulate nucleic acids, as well as other large molecules, in tiny particles and deliver them into the body. This fundamental research laid the foundation for MIT's most important contributions to confronting the Covid-19 virus nearly 40 years later.

Peter Fisher, professor and head of the Department of Physics, led a report by JASON, an independent group of scientists who advise the US government about science and technology in association with the MITRE Corporation. Fisher and other JASON members outlined steps needed for universities to safely return to research activities during the pandemic. MIT separately examined the question and began a phased ramp-up of lab research in June 2020; Fisher participated in MIT reopening efforts as well.

Arup Chakraborty, the Robert T. Haslam Professor in Chemical Engineering at MIT, and Andrey Shaw from Genentech wrote a book containing an overview of viruses and how they emerge to cause pandemics. The book, *Viruses, Pandemics, and Immunity*, explains how our immune system fights viruses, the science of epidemiological models, and how vaccines and therapies work. Chakraborty is also a professor of physics and of chemistry, a member of MIT's Institute for Medical Engineering and Science, and a member of the Ragon Institute.

Since the start of the Covid-19 pandemic, researchers at MIT and the Broad Institute, along with their collaborators at the University of Washington, the Fred Hutchinson Cancer Research Center, Brigham and Women's Hospital, and the Ragon Institute, have been working on a CRISPR-based diagnostic for Covid-19 that can produce results in 30 minutes to an hour at an accuracy level similar to that of the standard polymerase chain reaction diagnostics now used. Although the new test, known as STOPCovid, is still in the research stage, it could in principle be made cheaply enough that people could test themselves every day, according to researchers Jonathan Gootenberg and Omar Abudayyeh, fellows at the McGovern Institute for Brain Research, and Feng Zhang, a core member of the Broad Institute, an investigator at the McGovern Institute and the Howard Hughes Medical Institute, and the James and Patricia Poitras '63 Professor of Neuroscience at MIT. The first authors of the paper are MIT biological engineering graduate students Julia Joung and Alim Ladha from the Zhang lab.

MIT chemists led by Mei Hong have determined the molecular structure of a protein found in the SARS-CoV-2 virus. This protein, called envelope protein E, forms a cation-selective channel and plays a key role in the virus's ability to replicate itself and stimulate the host cell's inflammation response. If researchers can devise ways to block this channel, they may be able to reduce the pathogenicity of the virus and interfere with viral replication. In their study, the researchers investigated the binding sites of two drugs that block the channel; however, these drugs bind only weakly, so they would not be effective inhibitors of the E protein.

A team of MIT and Harvard University researchers led by Satrajit Ghosh, a principal research scientist at the McGovern Institute, showed that they can measure the effects of the pandemic on mental health by analyzing the language that people use to express their anxiety online. Using machine learning to analyze the text of more than 800,000 Reddit posts, the researchers were able to identify changes in the tone and content of language—including an overall increase in discussions about anxiety and suicide—that people used as the first wave of the Covid-19 pandemic progressed. Their analysis revealed several key changes in conversations about mental health. Also, Ghosh modified his VoiceUp app to integrate data from MIT Lincoln Laboratory researchers who found evidence of measurable indicators, called vocal biomarkers, of people infected with Covid-19 but not yet showing symptoms.

Researchers led by Rebecca Saxe, the John W. Jarve (1978) Professor in Brain and Cognitive Sciences and a member of the McGovern Institute, found that after one day of total isolation, the sight of people having fun together activates the same brain region that lights up when someone is hungry. Findings from cognitive scientists fit the intuitive idea that positive social interactions are a basic human need, and acute loneliness is an aversive state that motivates people to repair what is lacking, similar to hunger.

A model developed by MIT researchers including Christopher Rackauckas, an applied mathematics instructor, shows a direct link between the number of people who become infected and how effectively a state maintains its quarantine measures. As the pandemic continues to ebb and surge, policymakers could use the model to calculate the quarantine strength needed to keep a state's current infections below a certain number.

## Climate Science and Sustainability

A team of researchers at MIT, including Jeremiah Johnson, and elsewhere found a novel electrolyte that could enable a significant leap in the power per weight of next-generation batteries without sacrificing cycle life. The finding could make it possible for lithium-ion batteries, which now typically can store about 260 watt-hours per kilogram, to store about 420 watt-hours per kilogram—translating into longer ranges for electric cars and longer-lasting charges on portable devices.

Johnson also led a study appearing in *Nature* in which he demonstrated that chemists can now modify durable and heat-resistant thermoset plastics to retain their mechanical strength and degrade more easily. The approach could be applicable to a range of plastics and other polymers such as rubber.

An MIT study led by Jonathan Lauderdale, a research scientist in EAPS, points to a significant uncertainty in the way the “ocean pump”—the method by which the oceans store atmospheric carbon and an essential ingredient in any global climate forecast—is represented in climate models. Researchers estimate that the new uncertainty translates to about a five-year error in climate target projections.

## Astrophysics

Astronomers from MIT, including research affiliate William Bains, EAPS research scientists Clara Sousa-Silva and Janusz Petkowski, EAPS postdoc and MIT Kavli Institute affiliate Sukrit Ranjan, graduate student Zhuchang Zhan, and Class of 1941 Professor of Planetary Science Sara Seager, found evidence of phosphine, a gas associated with living organisms, in the habitable region of Venus’ atmosphere. The team concluded that if their observation is indeed associated with life, it must be some sort of “aerial” life form in Venus’ clouds. The potential for life on Venus rocked the astrobiology community, but additional research cast doubts on the data interpretation. However, the MIT-led *Nature Astronomy* paper helped accelerate research in interpreting potential biosignatures from other planets.

A team of astronomers including Kiyoshi Masui, assistant professor of physics in the MIT Kavli Institute, have developed the first catalogue of fast radio bursts (FRBs) detected by the Canadian Hydrogen Intensity Mapping Experiment (CHIME) stationary radio telescope. CHIME has nearly quadrupled the number of FRBs discovered to date, expanding the current library of known FRBs and yielding clues as to their properties. With more observations, astronomers hope soon to pin down the extreme origins of these curiously bright signals.

Astronomers at MIT and elsewhere observed as a supermassive black hole’s own corona, the ultrabright, billion-degree ring of high-energy particles that encircles a black hole’s event horizon, was abruptly destroyed and re-created in under just one year—a change in luminosity that should happen on time scales of many thousands to millions of years. Although the cause of this dramatic transformation is unclear, researchers including Erin Kara, assistant professor of physics and researcher at the MIT Kavli Institute, theorize that the source of the calamity may have been a star caught in the black hole’s gravitational pull.



## Laser Interferometer Gravitational-Wave Observatory

Researchers from the MIT Laser Interferometer Gravitational-Wave Observatory (LIGO) Lab, researchers reported observing that quantum fluctuations can “kick” objects as large as the 40-kilogram mirrors of the National Science Foundation’s LIGO Laboratory by  $10^{-20}$  meters—a displacement that was predicted by quantum mechanics for objects of this size but that had never before been measured. This work, reported in *Nature*, was deemed one of 2020’s top 10 discoveries by *Physics World* for the team that included Lee McCuller, an MIT Kavli Institute research scientist; graduate students Haocun Yu and Maggie Tse; Nergis Mavalvala; and Lisa Barsotti, an MIT Kavli Institute principal research scientist.

To make this measurement, the group used an instrument they designed and built called a quantum “light squeezer” that reduces quantum noise in an incoming laser beam by 15%. First reported in *Nature Physics* by lead author Nancy Aggarwal PhD ’19, it is the first system of its kind to work at room temperature, making it amenable to a compact, portable setup that can be added to high-precision experiments to improve laser measurements when quantum noise is a limiting factor. By reducing the quantum noise in the LIGO measurement, the team will ultimately help LIGO detect fainter, more distant sources of gravitational waves.

For example, a team led by MIT Kavli Institute graduate student Sylvia Biscoveanu has developed a method to tease out the very faint signals of primordial ripples from gravitational-wave data. Primordial gravitational waves, produced nearly 13.8 billion years ago, still echo through the universe today. But they are drowned out by the crackle of gravitational waves produced by more recent events such as colliding black holes and neutron stars.

## Transiting Exoplanet Survey Satellite

Managed by NASA’s Goddard Space Flight Center, the Transiting Exoplanet Survey Satellite (TESS) is an MIT-led mission headed by George Ricker, a senior research scientist at the MIT Kavli Institute. Harvard-Smithsonian astronomer David Latham ’61 currently leads the TESS science team along with Chris Burke, MIT Kavli Institute research scientist, and Natalia Guerrero, MIT Kavli Institute research associate and manager of TESS Objects of Interest (objects that are considered candidate exoplanets).

Since beginning scientific operations in July 2018, TESS has reported nearly 150 confirmed exoplanet discoveries, including the detection of a massive Neptune-sized planet with a density that is comparable to Earth, a “pi Earth” (an Earth-sized planet that orbits its star every 3.14 days), and four exoplanets orbiting a Sun-like star only 200 light-years from Earth. Further observation and statistical analysis are needed to confirm the objects of interest detected, and information should be shared publicly in real time to facilitate efforts to validate the data by telescopes, including NASA’s upcoming James Webb Space Telescope.

Additional partners include Northrop Grumman, based in Falls Church, VA; NASA’s Ames Research Center in California’s Silicon Valley; the Harvard-Smithsonian Center for Astrophysics in Cambridge; MIT’s Lincoln Laboratory in Lexington, MA; and the

Space Telescope Science Institute in Baltimore. More than a dozen universities, research institutes, and observatories worldwide are participants in the mission.

### **Aging Brain**

Spearheaded by Li-Huei Tsai, director of the Picower Institute for Learning and Memory and Picower Professor, and Michael Sipser, former dean of science, the Aging Brain Initiative was established in 2015 to support interdisciplinary research on Alzheimer's disease and other diseases of the aging brain.

One of the most significant genetic risk factors for developing Alzheimer's disease is a gene called APOE4, which is carried by almost half of all Alzheimer's patients. Appearing in *Science Translational Medicine*, a 2021 study led by Tsai and the late Susan Lindquist, former director of MIT's Whitehead Institute for Biomedical Research, shows that this gene has widespread effects on brain cells' ability to metabolize lipids and respond to stress. In studies of human brain cells and yeast cells, the researchers found that the APOE4 gene significantly disrupts brain cells' ability to carry out their normal functions. They also showed that treating these cells with extra choline, a widely available supplement that is considered safe for human use, could reverse many of these effects.

MIT neuroscientists including Ann Graybiel, an Institute Professor at MIT in the Department of Brain and Cognitive Sciences (BCS) and a member of the McGovern Institute, found that aging negatively affects a brain circuit critical for maintaining motivation to learn new things and engage in everyday activities. They also showed that they could boost the motivation of older mice to engage in certain learning activities by reactivating this circuit.

### **Additional Technologies and Discoveries**

Our reading abilities set us apart from other animal species, but a few thousand years is much too short a time frame for our brains to have evolved new areas specifically devoted to reading. To account for the development of this skill, scientists have hypothesized that parts of the brain that originally evolved for other purposes have been "recycled" for reading. Senior author James DiCarlo, Peter de Florez Professor of Neuroscience and an investigator in the McGovern Institute and the Center for Brains, Minds, and Machines, and postdoc Rishi Rajalingham led the MIT group's study, which appeared in *Nature Communications*.

In the first study to comprehensively track how different types of brain cells respond to the mutation that causes Huntington's disease, MIT neuroscientists found that a significant cause of death for an especially afflicted kind of neuron might be an immune response to genetic material errantly released by mitochondria. The work was led by Myriam Heiman, associate professor in the Department of Brain and Cognitive Sciences, the Picower Institute, and the Broad Institute.

Nancy Kanwisher, the Walter A. Rosenblith Professor of Cognitive Neuroscience and a member of the McGovern Institute, and colleagues have shown that the "fusiform face area," a brain region specialized for identifying faces, becomes active in people who have been blind since birth when they touch a three-dimensional model of a face with their hands. The finding suggests that this region does not require visual experience to

develop a preference for faces. Kanwisher is the senior author and postdoc N. Apurva Ratan Murty is the lead author of the study, which appeared in the *Proceedings of the National Academy of Sciences*.

Cryo-electron microscopy allows scientists to produce high-resolution, three-dimensional images of tiny molecules such as proteins. This technique works best for imaging proteins that exist in only one conformation, but MIT researchers have now developed a machine learning algorithm that helps them identify multiple possible structures a protein can take. MIT researchers including lead author and biology graduate student Ellen Zhong have reported on new artificial intelligence–based software for reconstructing multiple structures and motions of the imaged protein—a major goal in the protein science community. Joseph Davis, the Whitehead Career Development Assistant Professor in the Department of Biology, and Bonnie Berger, the Simons Professor of Mathematics and head of the Computation and Biology Group at the Computer Science and Artificial Intelligence Laboratory, are the senior authors of the study, which appeared in *Nature Methods*.

Berger and Bryan Bryson, an assistant professor of biological engineering at MIT and a member of the Ragon Institute, have devised a new way to computationally model viral escape based on models originally developed to analyze language. The model can predict which sections of viral surface proteins are more likely to mutate in a way that enables viral escape, and it can also identify sections that are less likely to mutate, making them good targets for new vaccines.

Pablo Jarillo-Herrero, the Cecil and Ida Green Professor of Physics, and other colleagues discovered an important, and unexpected, electronic property of graphene. In this work, which was reported in *Nature*, the researchers showed that bilayer graphene can be ferroelectric. This means that positive and negative charges in the material can spontaneously separate into different layers, and these layers, when sandwiched between atomically thin layers of boron nitride, are also biocompatible. This discovery could usher in new, faster information-processing paradigms. One potential application is in neuromorphic computing, which aims to replicate the neuronal cells in the body responsible for everything from behavior to memories.

## **Awards and Honors**

### **Faculty Awards and Honors**

Every year, academic and professional organizations honor numerous School of Science faculty members for their innovative research, as well as their service to the community. Individual reports from the school’s departments, labs, and centers will document these awards more completely, but certain honors deserve additional mention.

Three faculty members and one alumna were named winners of prizes awarded by the Breakthrough Prize Foundation honoring early-career achievements in the fields of physics and mathematics. Physicists Tracy Slatyer and Netta Engelhardt each received a 2021 New Horizons in Physics Prize, while mathematicians Lisa Piccirillo and Nina Holden PhD ’18 each received the 2021 Maryam Mirzakhani New Frontiers Prize recognizing outstanding early-career women in mathematics.

The National Academy of Sciences (NAS) awarded four MIT scientists with 2021 Academy Honors for major contributions to science. The awards recognized Pablo Jarillo-Herrero for contributions to the fields of nanoscience and nanotechnology through his discovery of correlated insulator behavior and unconventional superconductivity in magic-angle graphene superlattices, Aviv Regev for using interdisciplinary information or techniques to solve a contemporary challenge, Susan Solomon for contributions to understanding and communicating the causes of ozone depletion and climate change, and Feng Zhang for pioneering achievements in developing CRISPR tools with the potential to diagnose and treat disease.

NAS also named four School of Science professors among its 120 new members this year: Daniel Freedman, professor emeritus in the Departments of Mathematics and Physics; Larry Guth; Gigliola Staffilani; and Robert Guy Griffin, the Arthur Amos Noyes Professor of Chemistry and director of the Francis Bitter Magnet Laboratory.

The US Department of Energy named four MIT faculty to the 2021 Early Career Research Program, including three science faculty members: Riccardo Comin of the Department of Physics, Netta Engelhardt of the Department of Physics and the Center for Theoretical Physics, and Philip Harris of the Department of Physics and the Laboratory for Nuclear Science.

Six MIT faculty members were elected as fellows of the American Association for the Advancement of Science, including two in science: Catherine Drennan and Peter Fisher.

Jeremy Kepner, a Lincoln Laboratory Fellow in the Cyber Security and Information Sciences Division and a research affiliate of the Department of Mathematics, was named to the 2021 class of fellows of the Society for Industrial and Applied Mathematics.

The Alfred P. Sloan Foundation awarded 2021 Sloan Research Fellowships to eight MIT professors, including four science faculty members: Joseph Davis; Steven Flavell, the Lister Brothers Career Development Assistant Professor in Brain and Cognitive Sciences and the Picower Institute; and Assistant Professors of Mathematics Dor Minzer and Lisa Piccirillo.

Robert Weinberg, a professor of biology at MIT and a member of the Whitehead Institute, was one of three recipients of the 2021 Japan Prize in the Medical Science and Medicinal Science category for his contributions to the development of a multi-step model of how cancer begins and progresses and the application of that model to improve cancer treatments and outcomes.

Li-Huei Tsai was elected to the American Academy of Arts and Sciences with four other MIT faculty members.

The Society for Neuroscience awarded the Swartz Prize for Theoretical and Computational Neuroscience to Emery N. Brown, the Edward Hood Taplin Professor of Medical Engineering and Computational Neuroscience at MIT and a member of the Picower Institute.

Mark Vogelsberger, an associate professor of physics, received the 2020 Buchalter Cosmology Prize in a collaboration led by Phillip Mocz, a postdoc at Princeton University. Their research involved a novel simulation of the early universe with a theorized ultralight.

Class of 1957 Career Development Assistant Professor of Physics Phiala Shanahan received the 2020 Kenneth G. Wilson Award for Excellence in Lattice Field Theory.

Pablo Jarillo-Herrero was awarded the Lise Meitner Distinguished Lecture and Medal for his groundbreaking work on “twistronics,” a technique that adjusts the electronic properties of graphene by rotating adjacent layers of the material. He was also honored with the highest scientific recognition of the Spanish Royal Physics Society for this work. In addition, Jarillo-Herrero and Professor Nuh Gedik were named Experimental Investigators in Quantum Materials by the Gordon and Betty Moore Foundation.

The American Institute of Physics presented the 2020 Science Communication Award to Susan Hockfield, MIT president emerita and professor of neuroscience, for her 2019 book *The Age of Living Machines*.

The David and Lucile Packard Foundation named Daniel Harlow, assistant professor of physics and a researcher at the Center for Theoretical Physics, a Packard Fellow for Science and Engineering. The fellowship will support Harlow’s research in quantum computation to generate new insights about both black holes and quantum computers.

Associate Professor of Physics and Biology Ibrahim Cissé, Professor of Biology and Whitehead Institute director Ruth Lehmann, and Andria and Paul Heafy Whitehead Fellow Silvi Rouskin were awarded 2021 Vilcek Prizes for “outstanding contributions of immigrants in the sciences and the arts.”

Sara Seager was named an officer of the Order of Canada, one of the country’s highest civilian honors, for her “multidisciplinary research that has contributed to transforming the study of extrasolar planets into a full-fledged planetary science.”

### **Rewards and Recognition**

The School of Science Rewards and Recognition program continues to acknowledge the dedication and hard work of the people who fill our departments, labs, and centers and whose efforts are the source of our prestige. The school continues its Spot Awards, which recognize employees for going beyond the requirements of their normal duties.

The Infinite Expansion Awards (previously the Infinite Kilometer Awards) were created in 2012 to highlight the contributions of postdoctoral scholars and research scientists (or equivalents). This year’s winners included Xinqiang Ding (Chemistry), Quentin Ferry (Picower Institute), Hamed Ghaffari (EAPS), Andrew Grassetti (Biology), Sarah Heine (MIT Kavli Institute), Samantha Kristufek (Chemistry), Nathan Lourie (MIT Kavli Institute), Hiruy Meharena (Picower Institute), Alexander Schuppe (Chemistry), Jitendra Sharma (Picower Institute), Yong Wang (Chemistry), Jun Yang (MIT Kavli Institute), and Hannah Yevick (Biology).

## Personnel

### Appointments and Promotions

Joseph Checkelsky (Physics), Myriam Heiman (Brain and Cognitive Sciences), Kerstin Perez (Physics), Alexander Radosevich (Chemistry), and Alex K. Shalek (Chemistry) were granted tenure.

Riccardo Comin (Physics), Steven Flavell (Brain and Cognitive Sciences), Daniel Harlow (Physics), Or Hen (Physics), Peter Hintz (Mathematics), Sebastian Lourido (Biology), and Bin Zhang (Chemistry) were promoted to associate professor without tenure.

Daniel Álvarez-Gavela (Mathematics), Soonwon Choi (Physics), Olivia Corradin (Biology), Jeremy Hahn (Mathematics), Kristin Knouse (Biology), Lina Necib (Physics), Lisa Sauermann (Mathematics), Andrew Vanderberg (Physics), and Guangyu Robert Yang (Brain and Cognitive Sciences) joined the School of Science faculty as assistant professors.

Arlene Fiore, the Peter H. Stone and Paola Malanotte Stone Professor of Earth, Atmospheric and Planetary Sciences, and Danna Freedman of the Department of Chemistry joined the school as full professors with tenure.

John Belcher (Physics), Robert Field (Chemistry), Robert Jaffe (Physics), Haynes Miller (Mathematics), Robert Redwine (Physics), Paola Rizzoli (EAPS), and Lisa Steiner (Biology) retired from the School of Science.

The following changes in role occurred:

The Whitehead Institute selected Professor Ruth Lehmann, a world-renowned developmental and cell biology researcher, as the institute's fifth director. Lehmann succeeded David Page on July 1, 2020.

Nergis Mavalvala was named dean of science effective September 1, 2020.

James DiCarlo, outgoing head of the Department of Brain and Cognitive Sciences, was named director of the MIT Quest for Intelligence. Michale Fee, the Glen V. and Phyllis F. Dorflinger Professor of Brain and Cognitive Sciences, was named the new head of BCS effective May 1, 2021.

Matthew Vander Heiden, an MIT professor of biology and a pioneer in the field of cancer cell metabolism, was named the new director of MIT's Koch Institute for Integrative Cancer Research effective April 1, 2021. Vander Heiden succeeded David H. Koch Professor of Biology Tyler Jacks, who served as director for more than 19 years, first for the MIT Center for Cancer Research and then for its successor, the Koch Institute.

### Faculty Lunch Programs

Tenure-track faculty lunch meetings are intended to help junior faculty members meet their peers in different departments and to provide a forum for discussion of important issues, including supporting the faculty during this year of primarily remote instruction. This year's meetings featured a visit from Lincoln Laboratory, updates from Vice President of Human Resources Ramona Allen and Director of Human Resources Ronnie

Haas, a meet-the-dean event, and a faculty presentation by Bin Zhang, Pfizer-Laubach Career Development Associate Professor of Chemistry. Also, the dean hosted a faculty lunch in which participants discussed the most recent data from the school's Gender Equity Committee, co-chaired by Professor Michael Laub and Gigliola Staffilani.

Faculty lunch programs included sessions focused on advancing and supporting women in science. Nancy Hopkins, Amgen Professor of Biology emerita; Sangeeta Bhatia, John J. and Dorothy Wilson Professor of Health Sciences and Technology and of Electrical Engineering and Computer Science and director of the Marble Center for Cancer Nanomedicine; and Susan Hockfield hosted a conversation about the MIT Future Founders Initiative and increasing female entrepreneurship. Participants also met for continued discussion of the Gender Equity Committee report.

Finally, in a tenured faculty lunch meeting, BCS professor Roger Levy presented on the foundational computational architecture of human language understanding.

### **Learn@Lunch Series**

To provide administrative staff the support they need to do their jobs as effectively as possible, the school holds a monthly lunch-and-learn series for staff members. This year, presentations occurred more frequently and remotely. The series included sessions focused on helping staff working from home during the pandemic presented by members of MIT Medical, the MIT Center for WorkLife and WellBeing, and Human Resources, among others. The series also included sessions about the Institute's diversity, equity, and inclusion strategy led by John Dozier, Tim Jamison, and Maryanne Kirkbride.

### **School of Science Peer Mentoring**

The Peer-to-Peer mentoring program pairs new School of Science staff with mentors who will help them navigate job responsibilities, MIT policies and procedures, and Institute organization and culture. The program provides opportunities for both mentors and new employees to expand their skill sets, increase their confidence, and make connections with School of Science community members outside of their home department, lab, or center.

**Nergis Mavalvala**

**Dean**

**Curtis and Kathleen Marble Professor of Astrophysics**