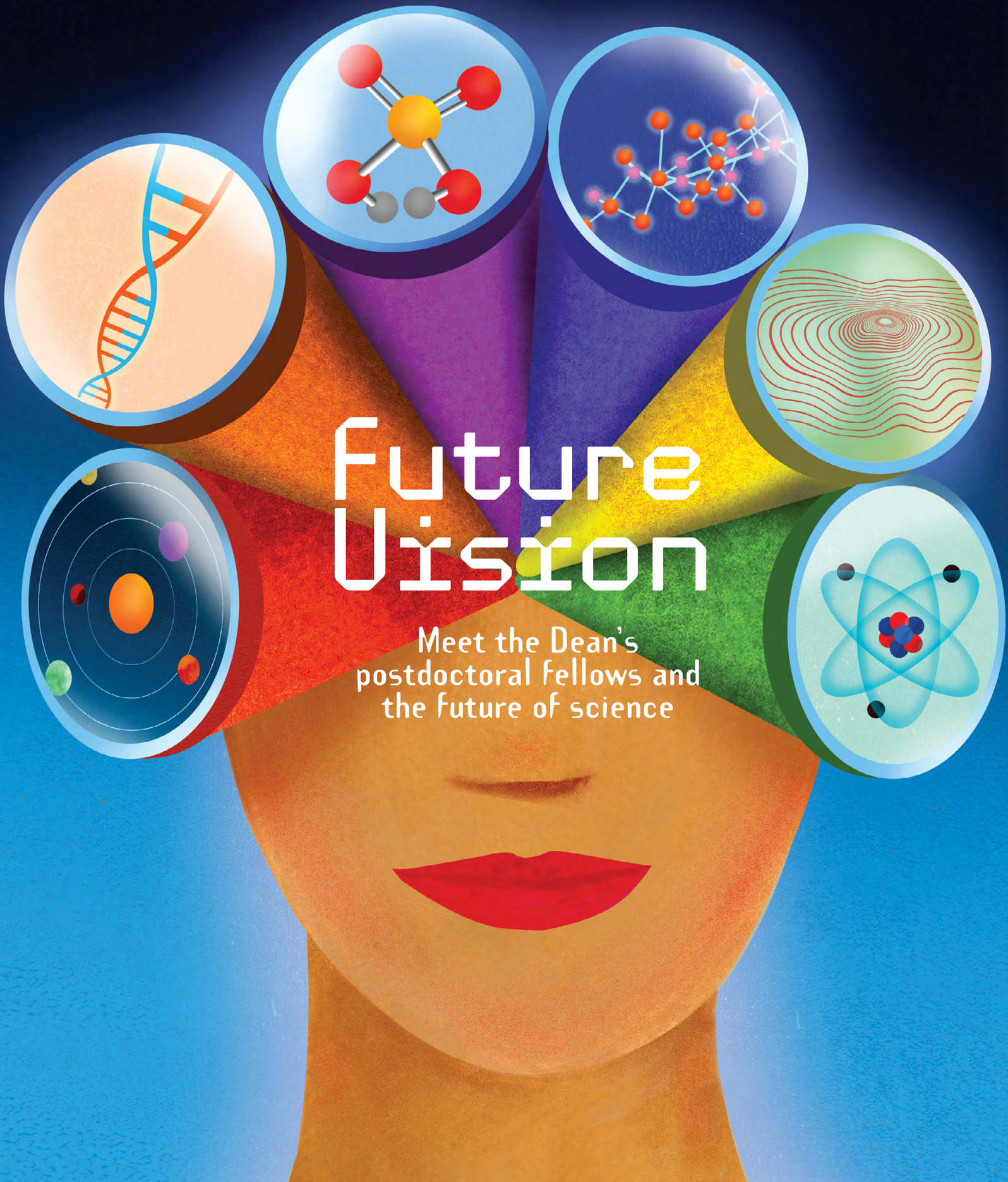
Science AT MIT

Winter 2026 | Published twice yearly



Future Vision

Meet the Dean's postdoctoral fellows and the future of science

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Letter from the Dean

Dear alumni and friends,

As we welcome a new year, I'm pleased to share this issue of *Science@MIT*. This issue reflects the vibrancy and depth of research across the School of Science, and the extraordinary people and partnerships driving our mission forward.

We begin by celebrating the launch of the School's new postdoctoral fellowship program, made possible by the Fund for the Future of Science. This fellowship program supports outstanding early-career researchers across disciplines — from quantum chemistry and atmospheric modeling to protein biology and mathematical physics. These fellows represent the next generation of scientific leadership, and their work exemplifies the intellectual curiosity and collaborative spirit that define MIT.

We are also thrilled to join the international consortium constructing the Giant Magellan Telescope (GMT), a $2.6 billion telescope in Chile that will redefine our view of the universe. Enabled by a visionary gift from Terry and Susan Ragon, MIT's participation strengthens U.S. leadership in astronomy and instrumentation, and opens up new opportunities for our researchers and students at the MIT Kavli Institute for Astrophysics and Space Research to explore the cosmos.

I'll never forget the moment that Terry walked into my office and said, with that unmistakable spark in his eye, "I want to support MIT joining the GMT." I knew then that something remarkable was about to unfold. It was a moment of clarity, generosity, and shared purpose that I will always treasure.

As we look toward a future with MIT scientists joining the GMT, I cannot help think of my beloved mentor, teacher, and colleague, the late Rai Weiss. Rai was not only a towering figure in astrophysics, but a beloved member of our MIT community. His pioneering work on gravitational wave detection through LIGO opened a new window on the universe, confirming Einstein's century-old predictions and forever changing how we observe the cosmos. Now, upon the 10th anniversary of the first gravitational wave detection, we can envision what LIGO and GMT will uncover when their powers combine.

This issue also highlights several transformative philanthropic gifts that are expanding the frontiers of research and education. A $20 million gift from the Leinweber Foundation, alongside a $5 million commitment from the School of Science, establishes the MIT Center for Theoretical Physics – A Leinweber Institute. This landmark investment will support graduate students, postdocs, and faculty in theoretical physics, and foster collaboration across a new national network of institutes.

Also in this issue, you'll read about the appointment of Professor Matthew Shoulders as the new head of the Department of Chemistry. A leading researcher in protein folding and engineering, Matt brings scientific excellence and a deep commitment to community building to the department.

You can read about a major advance in photosynthesis research from the Shoulders Lab, where MIT chemists have used directed evolution to improve the efficiency of rubisco — one of the most important and least efficient enzymes in nature. This work holds promise for enhancing crop yields and addressing food security through molecular innovation.

Finally, we recognize two major gifts in the Department of Biology. With funding from the W. M. Keck Foundation, Assistant Professor of Biology Alison Ringel will investigate the intersection of immunology and aging biology, aiming to define the mechanisms that underlie aging-related decline. In addition, the establishment of the Phil Sharp–Alnylam Fund for Emerging Scientists — a flexible funding resource created in honor of Nobel Laureate Phil Sharp and funded by Alnylam Pharmaceuticals — underscores the importance of sustaining the pipeline of scientific talent in a time of uncertain federal support.

Taken together, the stories in this issue reflect the power of partnership — between researchers and donors, between disciplines, and between generations. They remind us that science is not only a pursuit of knowledge, but a shared endeavor to improve the human condition.

Thank you for being part of our community. Your support helps us nurture talent, pursue bold ideas, and bolster a strong future for science.

With warm regards,

Dean Nergis Mavalvala PhD '97

Meet the Future of Science

Profiles written by Lyn Nanticha Ocharoenchai

This fall, MIT School of Science welcomes the first cohort of its prestigious postdoctoral fellowship program. Spanning all areas of science, these postdocs represent the future of their fields — and science's future discoveries.

Made possible by a generous grant from alumni and friends, the Fund for the Future of Science supports this new postdoctoral program, which is based on other successful postdoc programs such as Physics' Pappalardo Fellows program funded by A. Neil Pappalardo '64, an MIT alumnus with a long history of generosity to both the Institute and the Department of Physics.

Last issue, *Science@MIT* featured one of these talented young scientists, Jess Speedie. (See our Summer 2025 issue). Here, we present a shortened version of profiles for all of our new postdocs. You can read their full profiles at science.mit.edu, at their home department news pages, and at MIT News.

Amanda Burcroff

Unlocking mysteries of the cosmos through math

Amanda Burcroff's research is focused on algebraic combinatorics, an area that provides discrete frameworks for understanding algebraic and geometric spaces that ubiquitously arise across science. Working with Professor Alexander Postnikov in the Department of Mathematics, Burcroff aims to build upon her techniques with the goal of applying them to other fields such as theoretical physics — a field that seeks to uncover the fundamental laws governing everything from subatomic particles to the cosmos itself.

"I have trust that if you keep following the path, eventually you'll find the treasure — that is, whatever theorem or proof — that you're looking for," says Burcroff.

Exploring possibilities and redefining rules

In elementary school, Burcroff only saw math as a subject that entailed lots of memorizing. Although she felt that it came naturally to her, she didn't always find math very interesting.

In high school, as she came to learn about areas such as calculus and geometry, Burcroff started to see the discipline in a different light — a creative approach to exploring what's possible.

"[In] most other fields, the rules are imposed on you by the world," she says. "But in math, you get full freedom to lay down those rules and then figure out what the implications of those rules are by using logical consequence."

In 2015, Burcroff began her bachelor's degree at the University of Michigan with a major in math and a minor in computer science. There, she entered the world of

Amanda Burcroff, Mathematics. *Photo: Steph Stevens*

combinatorics — a branch of math dealing with counting, arranging, and combining objects that forms a crucial basis for understanding the complexity of problems as well as the limits of computer algorithms.

"When I was starting out, I was just happy to have any mystery that anyone gave me," she says.

Math was, to Burcroff, like a fun game with levels to complete. But during a study abroad program in Budapest, Hungary — the hometown of Paul Erdos, who is considered to be one of the most prolific mathematicians of the 20th century — it became more exciting to play when she was handed puzzles no one has yet solved.

"It turns out that if you put down the right set of rules, there's an infinite number of beautiful things that you can do with it," she says.

A journey of endless mysteries to unlock

In 2019, Burcroff embarked on a journey to pursue further research in England, later completing a master's degree in pure mathematics at the University of Cambridge then a research master's degree at Durham University. In 2021, she returned to the United States and began her PhD at Harvard University with the guidance of Professor Lauren Williams.

Among several riddles she has unraveled over the years, Burcroff helped unify different mathematical approaches to understand why systems work so reliably. Think of it as finding out that two seemingly different sets of instructions actually lead the same way. By demonstrating their connections, her work has revealed a fundamental mathematical architecture — a finding that later helped Burcroff and her collaborators tackle one of the many enduring riddles in her field.

Generalized cluster algebras form the basis for describing geometries that appear throughout physics. For more than a decade, mathematicians suspected these building blocks were created only by adding up ingredients and never subtracting, though no one was able to prove it. In 2024, Burcroff and her collaborators published a paper demonstrating that these spaces have nice positivity properties by developing a new way to count and organize patterns — helping untangle a long-standing conjecture, whose potential implications span from predicting particle collision outcomes to describing the spaces appearing in string theory.

Despite the tremendous number of problems she has answered, new ones keep arising. "Every time you unlock one of them, it gives you a bunch of paths to new connected mysteries," Burcroff says.

Sopuruchukwu Ezenwa

Cracking the catalysis code that powers a trillion-dollar industry

Sopuruchukwu Ezenwa, Chemistry. *Photo: Steph Stevens*

Electrochemistry — during which one reactant supplies electrons while another receives them — underpins many everyday phenomena like battery charging and iron rusting. While this field is becoming increasingly crucial with the global push toward renewable energy and decarbonization, current understanding of these many catalytic processes remains limited.

By bridging concepts from electrochemistry and thermochemical catalysis — historically studied separately — chemical engineer Sopuruchukwu Ezenwa is uncovering how electric fields that spontaneously form during reactions can be harnessed to influence how chemical transformations occur. This research offers vast potential in improving the selectivity and efficiency of many large-scale industrial catalytic processes where charge transfer reactions may play a key role.

Now working as a postdoc in the School of Science Dean's Fellow program at MIT's Department of Chemistry, Ezenwa's goal is to help make chemical manufacturing more effective and sustainable by developing better methods to study and control catalysis.

"How can we ensure that the ways that we produce chemicals and energy are much more efficient, in ways that they can serve our future generation? That's something I deeply care about," Ezenwa says.

Ezenwa grew up in Aba, a commercial hub of southern Nigeria where crude oil facilities dotted the landscape but electricity grids consistently failed. While energy has become more stable today, back then, outages would repeatedly happen for weeks and sometimes even months.

In 2012, he began studying petroleum engineering — a career that pays well in a nation that serves as Africa's largest oil producer. However, just shortly after, lecturers nationwide went on strike after the government failed to implement a previously agreed deal. With universities paralyzed for nearly half a year, Ezenwa decided to seek education abroad.

Ezenwa was accepted to study chemical engineering at Tufts University, with a full scholarship. At Tufts, Ezenwa was first captivated by the ubiquity of catalysis during a lecture by Prashant Deshlahra, a professor of chemical and biological engineering. With the guidance of Deshlahra — whose interest lies in reactions involving catalysts and reactants of different phases — he explored how to use catalysis to selectively guide hydrocarbon oxidation to form desired products.

In 2018, he carried his research on to Purdue University, where he worked with his PhD advisor, Rajamani Gounder, director of the Purdue Catalysis Center. There, he studied zeolites, a group of minerals containing aluminum and silicon oxides that are commonly found in nature, cheap to synthesize, and widely used in the chemical industry.

With physical properties resembling that of sand, zeolite's unique internal architecture is composed of uniform, interconnected pores and channels that allow certain molecules to enter while blocking others. Within this microscopic maze, highly reactive spots called Brønsted acid sites can drive desired chemical transformations once the right molecule enters them.

Using a combination of precise synthesis techniques and kinetic measurements, Ezenwa developed ways to control where these acid sites form within the zeolite's structure. By tracking reaction rates and product distributions, he also demonstrated that confining these reactive sites to smaller spaces could boost the selective production of para-xylene — a key ingredient in PET plastics — to 80 percent efficiency, compared to just 30 percent when the sites were scattered throughout larger pores.

At MIT, Ezenwa started to explore yet another new frontier. In late 2024, Ezenwa began studying electrochemical catalysis, a separate field from the thermochemical catalysis he focused on during his PhD. He now works as a postdoc with Donner Professor of Science Yogesh Surendranath, whose lab addresses challenges in energy conversion and sustainability by manipulating charge transfer reactions at catalytic interfaces.

"Ezenwa stood out because of his thirst to broaden his horizons during his postdoc," says Surendranath. "His interest in learning a field he'd never been exposed to really spoke to his intellectual curiosity and boldness."

Ursula Jongebloed

Learning about the Earth's climate by studying a history frozen in ice

Ursula Jongebloed, Earth, Atmospheric and Planetary Sciences. *Photo: Steph Stevens*

About 600 years ago, Greenland was home to just a few thousand Vikings and Inuit people. The air looked and felt very different compared to how it does today.

"In some ways, we still don't really know what the atmosphere looked like before humans started [polluting it]," says atmospheric chemist Ursula Jongebloed who has used ice cores to study this history.

This year, Jongebloed joins MIT's Department of Earth, Atmospheric and Planetary Sciences (EAPS) working with Arlene Fiore, the Peter H. Stone and Paola Malanotte Stone Professor and associate department head. She aims to use modeling to better understand how aerosols and oxidants have interacted with the atmosphere over the industrial era — addressing one of the biggest gaps in predicting future climate.

A love of learning

Growing up in San Francisco's Bay Area, she was awed by the coastal cliffs, redwoods, and tide pools she explored on school field trips and family vacations. In middle school, her fascination turned to the microscopic.

"When you look at a glass of water — to the eye, it doesn't really look that complicated, right?" she says. "But the reality is that things are constantly colliding, interacting, breaking apart, and forming new bonds was pretty mind-blowing to me when I learned that."

That curiosity led her to study chemistry and earth sciences at Dartmouth College. In one class on atmospheric

chemistry, she was struck by how much sea levels have risen and fallen and how drastically the polar ecosystems have changed over millions of years.

Today, as human activity accelerates those shifts, Jongebloed digs into Earth's frozen archives to understand what came before — and what might come next.

Digging up a frozen history

Over thousands of years, falling snow has compressed into ice and formed glaciers that preserve relics of the past. Whether insect fragments, pollen grains, volcanic ash, or air bubbles, each of these artifacts can help scientists paint a picture of life during each period. Among them, Jongebloed focuses on chemical traces called sulfate aerosols.

Typically formed during volcanic eruptions or the burning of fossil fuels when sulfur dioxide reacts with gases in the atmosphere, these tiny airborne particles play a critical role in cooling the planet by reflecting sunlight. To understand how sulfate sources and chemistry have changed over time, Jongebloed studied a 217-meter ice core collected from Greenland.

By analyzing the frozen cylinder — measuring about as long as two football fields placed end to end — Jongebloed and her team uncovered 650 years of atmospheric history from 1200 to 1850 C.E. that led to a series of findings.

In 2023, they published a paper revealing that dormant volcanoes quietly release up to three times as much sulfur into the Arctic atmosphere than estimated by current climate models. In the same year, they also showed that sulfur emissions from marine phytoplankton in the North Atlantic have remained relatively stable, in contrast to the declining populations suggested in previous studies.

In another paper, Jongebloed provided the first long-term record distinguishing natural from human-made sulfate sources in the Arctic.

"It was totally an 'A ha!' moment," she recalls.

At MIT, Jongebloed aims to expand her focus beyond sulfur by working with Fiore, whose lab at EAPS specializes in complex, computationally intensive models of atmospheric chemistry and pollution.

"I suspect she'll catalyze some new research directions while also serving as a bridge to the laboratory work in the Kroll Lab," says Fiore.

Jongebloed will also collaborate with Peter de Florez Professor Jesse Kroll, whose experimental research focuses on characterizing organic compounds in the Earth's atmosphere, which will help complement her modeling work.

Sergei Kotelnikou

Building the blocks of life

Billions of years ago, simple organic molecules drifted across Earth's primordial landscape — nothing more than basic chemical compounds. But as natural forces shaped the planet over hundreds of millions of years, these molecules began to interact and bond in increasingly complex ways. Along the way, something spectacular emerged: life.

"Life is to some degree magical," says computational biologist Sergei Kotelnikov. Simple organic compounds congregate into polymers, which assemble into living cells and ultimately organisms — the whole being greater than the sum of its parts.

Kotelnikov builds models to analyze and predict the structure of these biomolecules, particularly proteins, the fundamental building blocks of every organism. This year, he joined Professor Amy Keating's lab, where researchers focus on protein structure, function, and interaction. Using machine learning, his goal is to develop new methods in protein modeling with potential applications that span from medicine to agriculture.

A hunger for problems to solve

Kotelnikov grew up in Abakan, Russia, a small city located right in the center of Eurasia. As a child, one of his favorite pastimes was playing with LEGO. "It encouraged me to build new things, rather than just following instructions," he says. "You can do anything."

In 2012, Kotelnikov began his bachelor of science in physics and applied mathematics at the Moscow Institute of Physics and Technology — considered one of the world's leading STEM universities — and continued there for his master's degree. It was there that biology came into the picture.

Sergei Kotelnikov, Biology. *Photo: Steph Stevens*

During a course on statistical physics, Kotelnikov was first introduced to the idea of the "emergence of complexity." He became fascinated by this "mysterious and attractive manifestation of biology ... this evolution that sharpens the physical phenomenon" to create, drive, and shape life as we know it today. By the time he completed his master's degree, he realized he had only scratched surface of the field of computational biology.

In 2018, he began his PhD at Stony Brook University in New York and began working with Dima Kozakov, who is recognized as one of the world's leaders in predicting protein interactions and complex structures.

Studying the architecture of life

Proteins are like the building blocks that construct an organism, underpinning almost nearly every cellular process from tissue repair to hormone production. Like pieces of a LEGO tower, their structures and interactions determine the functions that they carry out in a body.

However, diseases arise when proteins are folded, curled, twisted, or connected in unusual ways. To develop medical interventions, scientists break down the tower and examine each individual piece to find the culprit and correct their shape and pairing. With limited experimental data on protein structures and interactions currently available, simulations developed by computational biologists such as Kotelnikov provide crucial insight that inform fundamental understanding and applications like drug discovery.

With the guidance of Kozakov at Stony Brook's Laufer Center for Physical and Quantitative Biology, Kotelnikov carried over his understanding of physics to create modeling methods that are more effective, efficient, reliable, and generalizable. Among them, he developed a new way of predicting the complex structures mediated by proteolysis-targeting chimeras, or PROTACs, a new class of molecules that can trigger the breakdown of specific proteins previously considered undruggable, such as those found in cancer.

At MIT, Kotelnikov will work with Amy Keating, department head and Jay A. Stein (1968) Professor to study protein structure, function, and interactions.

By infusing physics with machine learning, Kotelnikov's goal is to advance modeling methods that can vastly inform applications such as cancer immunology and crop protection.

Kotelnikov is also planning to work with Professors Tommi Jaakkola and Tess Smidt in MIT's Department of Electrical Engineering and Computer Science to explore a field called geometric deep learning. In particular, he aims to integrate physical and geometric knowledge about biomolecules into neural network architectures and learning procedures.

Ernest Opoku

Quantum modeling for breakthroughs in materials science and sustainable energy

Ernest Opoku knew he wanted to become a scientist since he was a child. But his school in Dadease, a small town in Ghana, offered no elective science courses — so Opoku created one for himself.

Even though his school had neither a dedicated science classroom nor a lab, Opoku convinced his principal to bring in someone to teach him and five other friends he had convinced to join him. With just a chalkboard and some imagination, they learned about chemical interactions through the formulas and diagrams they drew together.

"I grew up in a town where it was difficult to find a scientist," says Opoku, who is now a quantum chemist.

This year, he joins MIT as a part of Haslam and Dewey Professor of Chemistry Troy Van Voorhis' research group in the Department of Chemistry. Opoku's goal is to advance computational methods to study how electrons behave — fundamental research that underlies applications ranging from materials science to drug discovery.

In pursuit of knowledge

"As a boy who wanted to satisfy my own curiosities at a young age, in addition to the fact that my parents had minimal formal education," Opoku says, "I knew that the only way I would be able to accomplish my goal was to work hard."

■ Ernest Opoku, Chemistry. *Photo: Steph Stevens*

He studied diligently and was able to get into one of Ghana's top high schools — but his parents couldn't afford the tuition. He therefore enrolled in Dadease Agric Senior High School in his hometown. By growing tomatoes and maize, he saved up enough money to support his education.

In 2012, he got into Kwame Nkrumah University of Science and Technology, a first-ranking university in Ghana and the West Africa region. There, he was introduced to computational chemistry. Unlike many other branches of science, the field required only a laptop and access to the internet to study chemical reactions.

"Anything that comes to mind, anytime I can grab my computer and I'll start exploring my curiosity. I don't have to wait to go to the laboratory in order to interrogate nature," he says.

In 2020, Opoku's curiosity brought him even further, this time overseas to Auburn University in Alabama for his PhD. Under the guidance of his advisor Professor J. V. Ortiz, Opoku contributed to the development of new computational methods to simulate how electrons bind to or detach from molecules, a process known as electron propagation.

What is new about Opoku's approach is that it does not rely on any adjustable or empirical parameters. Unlike some earlier computational methods that require tuning to match experimental results, his technique uses advanced mathematical formulations to directly account for first principles of electron interactions. This makes the method more accurate — closely resembling results from lab experiments — while using less computational power.

By streamlining the calculations and eliminating guesswork, Opoku's work marks a major step toward faster, more trustworthy quantum simulations across a wide range of molecules (including those never studied before), laying the groundwork for breakthroughs in many areas, such as materials science and sustainable energy.

For his postdoctoral research at MIT, Opoku aims to advance electron propagator methods to address larger and more complex molecules and materials by integrating quantum computing, machine learning, and bootstrap embedding — a technique that simplifies quantum chemistry calculations by dividing large molecules into smaller, overlapping fragments. He is collaborating with Van Voorhis, whose expertise in these areas can help make Opoku's advanced simulations more computationally efficient and scalable.

"His approach is different from any of the ways that we've pursued in the group in the past," Van Voorhis says of Opoku.

Jess Speedie

Jess Speedie, Earth, Atmospheric and Planetary Sciences.
Photo courtesy of the Heising-Simons Foundation

In addition to being a Science postdoc fellow, Jess Speedie is also a 51 Pegasi B fellow who received her PhD in astronomy at the University of Victoria in Canada. She is hosted by the Department of Earth, Atmospheric and Planetary Sciences and is working with Richard Teague, the Kerr-McGee Career Development Professor. In her research, Speedie uses a combination of observational data and simulations to study the birth of planets and the processes of planetary formation.

Speedie's work has focused on understanding cosmic nurseries and the detection and characterization of the youngest planets in the galaxy. A lot of this work has made use of the Atacama Large Millimeter/submillimeter Array (ALMA), located in northern Chile. Made up of a collection of 66 parabolic dishes, ALMA studies the universe with radio wavelengths, and Speedie has developed a novel approach to find signals in the data of gravitational instability in protoplanetary disks, a method of planetary formation.

Read the original profile of Speedie in the Summer 2025 of *Science@MIT*.

$20 million gift supports theoretical physics research and education at MIT

Gift from the Leinweber Foundation, in addition to a $5 million commitment from the School of Science, will drive discovery, collaboration, and the next generation of physics leaders

Julia C. Keller | School of Science

Leinweber Foundation gifts to seven institutions, exceeding $100 million, will establish the newly renamed MIT Center for Theoretical Physics – A Leinweber Institute within the Department of Physics, affiliated with the Laboratory for Nuclear Science at the School of Science, as well as Leinweber Institutes for Theoretical Physics at four other top research universities: Stanford University, University of Michigan, University of California at Berkeley, and University of Chicago; as well as a Leinweber Forum for Theoretical Physics at Caltech and a Leinweber Forum for Theoretical and Quantum Physics at the Institute for Advanced Study.

"MIT has one of the strongest and broadest theory groups in the world," says Professor Washington Taylor, the director of the newly funded center and a leading researcher in string theory and its connection to observable particle physics and cosmology.

"This landmark endowment from the Leinweber Foundation will enable us to support the best graduate students and postdoctoral researchers to develop their own independent research programs and to connect with other researchers in the Leinweber Institute network. By pledging to support this network and fundamental curiosity-driven science, Larry Leinweber and his family foundation have made a huge contribution to maintaining a thriving scientific enterprise in the United States in perpetuity."

Larry Leinweber. *Photo courtesy of the Leinweber Foundation*

The Leinweber Foundation's investment across five institutions — constituting the largest philanthropic commitment ever for theoretical physics research, according to the Science Philanthropy Alliance, a nonprofit organization that supports philanthropic support for science — will strengthen existing programs at each institution and foster collaboration across the universities. Recipient institutions will work both independently and collaboratively to explore foundational questions in theoretical physics. Each institute will continue to shape its own research focus and programs, while also committing to big-picture, cross-institutional convenings around topics of shared interest. Moreover, each institute will have significantly more funding for graduate students and postdocs, including fellowship support for three to eight fully endowed Leinweber Physics Fellows at each institute.

"This gift is a commitment to America's scientific future," says Larry Leinweber, founder and president of the Leinweber Foundation. "Theoretical physics may seem abstract to many, but it is the tip of the spear for innovation. It fuels our understanding of how the world works and opens the door to new technologies that can shape society for generations. As someone who has had a lifelong fascination with theoretical physics, I hope this investment not only strengthens U.S. leadership in basic science, but also inspires curiosity, creativity, and groundbreaking discoveries for generations to come."

The gift to MIT will create a postdoc program that, once fully funded, will initially provide support for up to six postdocs, with two selected per year for a three-year program. In addition, the gift will provide student financial support, including fellowship support, for up to six graduate students per year studying theoretical physics. The goal is to attract the top talent to the MIT Center for Theoretical Physics – A Leinweber Institute and support the ongoing research programs in a more robust way.

The MIT Center for Theoretical Physics – A Leinweber Institute will receive a $20 million gift from the Leinweber Foundation to support a postdoc fellowship program and research programs. Photo: *Peter Vanderwarker*

A portion of the funding will also provide support for visitors, seminars, and other scholarly activities of current postdocs, faculty, and students in theoretical physics, as well as helping with administrative support.

"Graduate students are the heart of our country's scientific research programs. Support for their education to become the future leaders of the field is essential for the advancement of the discipline," says Nergis Mavalvala, dean of the MIT School of Science and the Curtis (1963) and Kathleen Marble Professor of Astrophysics.

The Leinweber Foundation gift is the second significant gift for the center. "We are always grateful to Virgil Elings, whose generous gift helped make possible the space that houses the center," says Deepto Chakrabarty, head of the Department of Physics. Elings PhD '66, co-founder of Digital Instruments, which designed and sold scanning probe microscopes, made his gift more than 20 years ago to support a space for theoretical physicists to collaborate.

"Gifts like those from Larry Leinweber and Virgil Elings are critical, especially now in this time of uncertain funding from the federal government for support of fundamental scientific research carried out by our nation's leading postdocs, research scientists, faculty, and students," adds Mavalvala.

Professor Tracy Slatyer, whose work is motivated by questions of fundamental particle physics — particularly the nature and interactions of dark matter — will be the subsequent director of the MIT Center for Theoretical Physics – A Leinweber Institute beginning this fall. Slatyer will join Mavalvala, Taylor, Chakrabarty, and the entirety of the theoretical physics community for a dedication ceremony planned for the near future.

The Leinweber Foundation was founded in 2015 by software entrepreneur Larry Leinweber, and has worked with the Science Philanthropy Alliance since 2021 to shape its philanthropic strategy. "It's been a true pleasure to work with Larry and the Leinweber family over the past four years and to see their vision take shape," says France Córdova, president of the Science Philanthropy Alliance. "Throughout his life, Larry has exemplified curiosity, intellectual openness, and a deep commitment to learning. This gift reflects those values, ensuring that generations of scientists will have the freedom to explore, to question, and to pursue ideas that could change how we understand the universe."

New MIT initiative seeks to transform rare brain disorders research

The Rare Brain Disorders Nexus aims to accelerate the development of novel therapies for a spectrum of uncommon brain diseases

Rubina Veerakone | McGovern Institute for Brain Research

More than 300 million people worldwide are living with rare disorders — many of which have a genetic cause and affect the brain and nervous system — yet the vast majority of these conditions lack an approved therapy. Because each rare disorder affects fewer than 65 out of every 100,000 people, studying these disorders and creating new treatments for them is especially challenging.

Thanks to a generous philanthropic gift from Ana Méndez '91 and Rajeev Jayavant '86, '88, SM '88, MIT is now poised to fill gaps in this research landscape. By establishing the Rare Brain Disorders Nexus — or RareNet — at MIT's McGovern Institute for Brain Research, the alumni aim to convene leaders in neuroscience research, clinical medicine, patient advocacy, and industry to streamline the lab-to-clinic pipeline for rare brain disorder treatments.

"Ana and Rajeev's commitment to MIT will form crucial partnerships to propel the translation of scientific discoveries into promising therapeutics and expand the Institute's impact on the rare brain disorders community," says MIT president Sally Kornbluth. "We are deeply grateful

Ana Méndez '91 and Rajeev Jayavant '86, '88, SM '88 have established the Rare Brain Disorders Nexus at MIT's McGovern Institute for Brain Research.
Photo: Veronique Kherian

> “RareNet pioneers a unique model for biomedical research — one that is reimagining the role academia can play in developing therapeutics.”

for their pivotal role in advancing such critical science and bringing attention to conditions that have long been overlooked.”

Building new coalitions

Several hurdles have slowed the lab-to-clinic pipeline for rare brain disorder research. It is difficult to secure a sufficient number of patients per study, and current research efforts are fragmented, since each study typically focuses on a single disorder (there are more than 7,000 known rare disorders, according to the World Health Organization). Pharmaceutical companies are often reluctant to invest in emerging treatments due to a limited market size and the high costs associated with preparing drugs for commercialization.

Méndez and Jayavant envision that RareNet will finally break down these barriers. “Our hope is that RareNet will allow leaders in the field to come together under a shared framework and ignite scientific breakthroughs across multiple conditions. A discovery for one rare brain disorder could unlock new insights that are relevant to another,” says Jayavant. “By congregating the best minds in the field, we are confident that MIT will create the right scientific climate to produce drug candidates that may benefit a spectrum of uncommon conditions.”

Guoping Feng, the James W. (1963) and Patricia T. Poitras Professor in Neuroscience and associate director of the McGovern Institute, will serve as RareNet’s inaugural faculty director. Feng holds a strong record of advancing studies on therapies for neurodevelopmental disorders, including autism spectrum disorders, Williams syndrome, and uncommon forms of epilepsy. His team’s gene therapy for Phelan-McDermid syndrome, a rare and profound autism spectrum disorder, has been licensed to Jaguar Gene Therapy and is currently undergoing clinical trials. “RareNet pioneers a unique model for biomedical research — one that is reimagining the role academia can play in developing therapeutics,” says Feng.

RareNet plans to deploy two major initiatives: a global consortium and a therapeutic pipeline accelerator. The consortium will form an international network of researchers, clinicians, and patient groups from the outset. It seeks to connect siloed research efforts, secure more patient samples, promote data sharing, and drive a strong sense of trust and goal alignment across the RareNet community. Partnerships within the consortium will support the aim of the therapeutic pipeline accelerator: to de-risk early lab discoveries and expedite their translation to clinic. By fostering more targeted collaborations — especially between academia and industry — the accelerator will prepare potential treatments for clinical use as efficiently as possible.

MIT labs are focusing on four uncommon conditions in the first wave of RareNet projects: Rett syndrome, prion disease, disorders linked to SYNGAP1 mutations, and Sturge-Weber syndrome. The teams are working to develop novel therapies that can slow, halt, or reverse dysfunctions in the brain and nervous system.

These efforts will build new bridges to connect key stakeholders across the rare brain disorders community and disrupt conventional research approaches. “Rajeev and I are motivated to seed powerful collaborations between MIT researchers, clinicians, patients, and industry,” says Méndez. “Guoping Feng clearly understands our goal to create an environment where foundational studies can thrive and seamlessly move toward clinical impact.”

“Patient and caregiver experiences, and our foreseeable impact on their lives, will guide us and remain at the forefront of our work,” Feng adds. “For far too long has the rare brain disorders community been deprived of life-changing treatments — and, importantly, hope. RareNet gives us the opportunity to transform how we study these conditions, and to do so at a moment when it’s needed more than ever.”

New gift expands mental illness studies at Poitras Center for Psychiatric Disorders Research

A commitment from longtime supporters Patricia and James Poitras ’63 initiates multidisciplinary efforts to understand and treat complex psychiatric disorders

Julie Pryor | McGovern Institute for Brain Research

One in every eight people — 970 million globally — live with mental illness, according to the World Health Organization, with depression and anxiety being the most common mental health conditions worldwide. Existing therapies for complex psychiatric disorders like depression, anxiety, and schizophrenia have limitations, and federal funding to address these shortcomings is growing increasingly uncertain.

Patricia and James Poitras ’63 have committed $8 million to the Poitras Center for Psychiatric Disorders Research to launch pioneering research initiatives aimed at uncovering the brain basis of major mental illness and accelerating the development of novel treatments.

“Federal funding rarely supports the kind of bold, early-stage research that has the potential to transform our understanding of psychiatric illness. Pat and I want to help fill that gap — giving researchers the freedom to follow their most promising leads, even when the path forward isn’t guaranteed,” says James Poitras, who is chair of the McGovern Institute for Brain Research Board.

Their latest gift builds upon their legacy of philanthropic support for psychiatric disorders research at MIT, which now exceeds $46 million.

“With deep gratitude for Jim and Pat’s visionary support, we are eager to launch a bold set of studies aimed at unraveling the neural and cognitive underpinnings of major mental illnesses,” says Professor Robert Desimone, director of the McGovern Institute, home to the Poitras Center. “Together, these projects represent a powerful step toward transforming how we understand and treat mental illness.”

A legacy of support

Soon after joining the McGovern Institute Brain Research Board in 2006, the Poitrases made a $20 million commitment to establish the Poitras Center for Psychiatric Disorders Research at MIT. The center’s goal, to improve human health by addressing the root causes of complex psychiatric disorders, is deeply personal to them both.

“We had decided many years ago that our philanthropic efforts would be directed toward psychiatric research. We could not have imagined then that this perfect synergy between research at MIT’s McGovern Institute and our own philanthropic goals would develop,” recalls Patricia.

The center supports research at the McGovern Institute and collaborative projects with institutions such as the Broad Institute of MIT and Harvard, McLean Hospital, Mass General Brigham, and other clinical research centers. Since its establishment in 2007, the center has enabled advances in psychiatric research including the development of a machine learning “risk calculator” for bipolar disorder, the use of brain imaging to predict treatment outcomes for anxiety, and studies demonstrating that mindfulness can improve mental health in adolescents.

For the past decade, the Poitrases have also fueled breakthroughs in the lab of McGovern investigator and MIT professor Feng Zhang, backing the invention of powerful CRISPR systems and other molecular tools that are transforming biology and medicine. Their support has enabled the Zhang team to engineer new delivery vehicles for gene therapy, including vehicles capable of carrying genetic payloads that were once out of reach. The lab has also advanced innovative RNA-guided gene engineering tools such as NovaIscB, published in *Nature Biotechnology* in May 2025. These revolutionary genome editing and delivery technologies hold promise for the next generation of therapies needed for serious psychiatric illness.

In addition to fueling research in the center, the Poitras family has gifted two endowed professorships — the James and Patricia Poitras Professor of Neuroscience at MIT,

currently held by Feng Zhang, and the James W. (1963) and Patricia T. Poitras Professor of Brain and Cognitive Sciences at MIT, held by Guoping Feng — and an annual postdoctoral fellowship at the McGovern Institute.

New initiatives at the Poitras Center

The Poitras family's latest commitment to the Poitras Center will launch an ambitious set of new projects that bring together neuroscientists, clinicians, and computational experts to probe underpinnings of complex psychiatric disorders including schizophrenia, anxiety, and depression. These efforts reflect the center's core mission: to speed scientific discovery and therapeutic innovation in the field of psychiatric brain disorders research.

McGovern cognitive neuroscientists Evelina Fedorenko PhD '07, an associate professor, and Nancy Kanwisher '80, PhD '86, the Walter A. Rosenblith Professor of Cognitive Neuroscience — in collaboration with psychiatrist Ann Shinn of McLean Hospital — will explore how altered inner speech and reasoning contribute to the symptoms of schizophrenia. They will collect functional MRI data from individuals diagnosed with schizophrenia and matched controls as they perform reasoning tasks. The goal is to identify the brain activity patterns that underlie impaired reasoning in schizophrenia, a core cognitive disruption in the disorder.

A complementary line of investigation will focus on the role of inner speech — the "voice in our head" that shapes thought and self-awareness. The team will conduct a large-scale online behavioral study of neurotypical individuals to analyze how inner speech characteristics correlate with schizophrenia-spectrum traits. This will be followed by neuroimaging work comparing brain architecture among individuals with strong or weak inner voices and people with schizophrenia, with the aim of discovering neural markers linked to self-talk and disrupted cognition.

A different project led by McGovern neuroscientist and MIT Associate Professor Mark Harnett and 2024–2026 Poitras Center Postdoctoral Fellow Cynthia Rais focuses on how ketamine — an increasingly used antidepressant — alters brain circuits to produce rapid and sustained improvements in mood. Despite its clinical success, ketamine's mechanisms of action remain poorly understood. The Harnett Lab is using sophisticated tools to track how ketamine affects synaptic communication and large-scale brain network dynamics, particularly in models of treatment-resistant depression. By mapping these changes at both the cellular and systems levels, the team hopes to reveal how ketamine lifts mood so quickly — and inform the development of safer, longer-lasting antidepressants.

Guoping Feng is leveraging a new animal model of depression to uncover the brain circuits that drive major depressive disorder. The new animal model provides a powerful system for studying the intricacies of mood regulation. Feng's team is using state-of-the-art molecular tools to identify the specific genes and cell types involved in this circuit, with the goal of developing targeted treatments that can fine-tune these emotional pathways.

Patricia (right) and James Poitras '63 (center) with Guoping Feng, the James W. (1963) and Patricia T. Poitras Professor of Brain and Cognitive Sciences at MIT. *Photo: Justin Knight*

"This is one of the most promising models we have for understanding depression at a mechanistic level," says Feng, who is also associate director of the McGovern Institute. "It gives us a clear target for future therapies."

Another novel approach to treating mood disorders comes from the lab of Peter de Florez Professor James DiCarlo, who is exploring the brain's visual-emotional interface as a therapeutic tool for anxiety. The amygdala, a key emotional center in the brain, is heavily influenced by visual input. DiCarlo's lab is using advanced computational models to design visual scenes that may subtly shift emotional processing in the brain — essentially using sight to regulate mood. Unlike traditional therapies, this strategy could offer a noninvasive, drug-free option for individuals suffering from anxiety.

Together, these projects exemplify the kind of interdisciplinary, high-impact research that the Poitras Center was established to support.

"Mental illness affects not just individuals, but entire families who often struggle in silence and uncertainty," adds Patricia Poitras. "Our hope is that Poitras Center scientists will continue to make important advancements and spark novel treatments for complex mental health disorders and, most of all, give families living with these conditions a renewed sense of hope for the future."

Where the ocean and atmosphere communicate

Professor Abigail Bodner studies the role of ocean turbulence in climate patterns

Mark Sullivan | Earth, Atmospheric and Planetary Sciences

From a computer-lined office in the Green Building on MIT's campus, climate scientist Abigail Bodner monitors the world's oceans, bringing a mathematician's eye to gauging interactions between wind and wave.

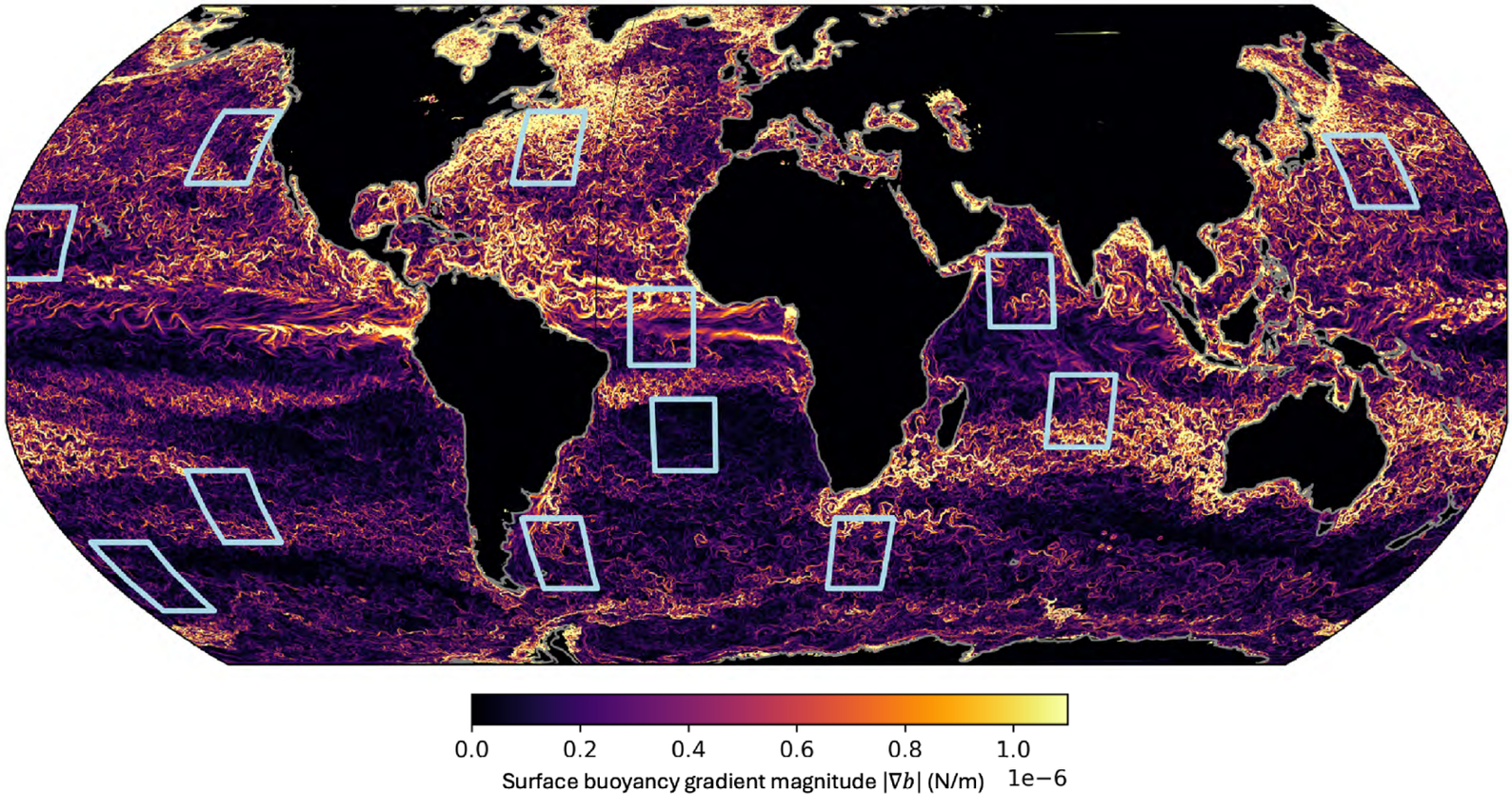
"I am fascinated by the way mathematics can describe fluid motion," says Bodner, a self-described "desk oceanographer" who is an assistant professor in the Department of Earth, Atmospheric and Planetary Sciences. She holds an MIT Schwarzman College of Computing shared position with the Department of Electrical Engineering and Computer Science, which is housed jointly in the College and the School of Engineering.

Through her research into localized ocean turbulence and its impact on climate patterns, she seeks to improve larger-scale climate models, leading to better projections of long-term changes, such as sea level rise, that are important to coastal communities.

Applying math and theory to natural phenomena

Bodner uses AI tools, satellite imagery, and data from idealized and more realistic simulations in her studies of complex ocean–atmosphere interactions.

"I was interested in math and earth sciences and ended up focusing on fluid dynamics, which combines the best of both worlds," she says. "It's a way we can explain natural phenomena with equations and physics. I got excited by the possibility of being able to see something and then write down this super complex mathematical form."



Bodner's research focuses on the role of turbulence in the ocean's upper layer, which plays a significant role in global climate regulation.
Image courtesy of the researchers

"More recently, I've started using computational tools, including different types of model simulations. AI is emerging in ocean observation products. It has been interesting to be able to combine computational tools and theory together with explaining natural phenomena and their impact."

Bodner came to MIT in 2024, previously having been a Simons Junior Fellow at the Courant Institute of Mathematical Sciences at New York University. She received her BS in geophysics and mathematics and MS in geophysics from Tel Aviv University, and her MS in applied mathematics and PhD in earth, environmental, and planetary sciences from Brown University.

She cofounded and directs an online summer program, Climatematch Academy, that has trained thousands of users from diverse backgrounds around the world to engage climate challenges using cutting-edge techniques.

"I am passionate about teaching and am especially motivated to teach computational tools for climate science," says Bodner. "I believe it is critical that the future generation of scientists are properly trained to use the wealth of climate data and tools available on open-source platforms."

> "I am fascinated by the way mathematics can describe fluid motion."

Abigail Bodner. *Photo courtesy of the faculty*

Monitoring the interaction of ocean and atmosphere on a local scale

Her research focuses on the role of turbulence in the upper, or topmost, layer of the ocean, where the exchange of heat and energy with the atmosphere occurs, playing a significant role in global climate regulation.

"The ocean and the atmosphere communicate through that upper layer through turbulence," she says. "It's an interesting mathematical and physical problem, too small to capture from theories we've developed for large-scale ocean circulation, but too big to be captured in a tank or classroom experiment. Beyond the theoretical mathematical perspective, this hyperlocal phenomenon can impact the global climate."

Global models are used in long-term projections of changes in sea surface temperatures, in rising sea levels, and in "what our climate system is going to be doing over the next hundred years," she says. But the grid used in the global model doesn't resolve a particular geographic locality such as Boston, which occupies a mere pixel or grid point in the model.

"Any kind of local effects we need to plan for over the next few decades are going to be informed by this coarse model," she observes. "And then the question is, do we have the right information? Improving our understanding of what happens on a smaller scale, on the order of one kilometer or less, will better inform long-term projections on the larger scale."

Matthew Shoulders named head of the Department of Chemistry

A leading researcher in protein folding biochemistry and next-generation protein engineering techniques will advance chemistry research and education

Julia C. Keller | School of Science

Matthew D. Shoulders named head of the Department of Chemistry, effective Jan. 16, 2026. *Photo: Justin Knight*

Matthew D. Shoulders, the Class of 1942 Professor of Chemistry, a MacVicar Faculty Fellow, and an associate member of the Broad Institute of MIT and Harvard, has been named head of the MIT Department of Chemistry, effective Jan. 16, 2026.

"Matt has made pioneering contributions to the chemistry research community through his research on mechanisms of proteostasis and his development of next-generation techniques to address challenges in biomedicine and agriculture," says Nergis Mavalvala, dean of the MIT School of Science and the Curtis (1963) and Kathleen Marble Professor of Astrophysics. "He is also a dedicated educator, beloved by undergraduates and graduates alike. I know the department will be in good hands as we double down on our commitment to world-leading research and education in the face of financial headwinds."

Shoulders succeeds Troy Van Voorhis, the Robert T. Haslam and Bradley Dewey Professor of Chemistry, who has been at the helm since October 2019.

"I am tremendously grateful to Troy for his leadership the past six years, building a fantastic community here in our department. We face challenges, but also many exciting opportunities, as a department in the years to come," says Shoulders. "One thing is certain: chemistry innovations are critical to solving pressing global challenges. Through the research that we do and the scientists we train, our department has a huge role to play in shaping the future."

Shoulders studies how cells fold proteins, and he develops and applies novel protein engineering techniques to challenges in biotechnology. His work across chemistry and biochemistry fields including proteostasis, extracellular matrix biology, virology, evolution, and synthetic biology is yielding not just important insights into topics like how cells build healthy tissues and how proteins evolve, but also influencing approaches to disease therapy and biotechnology development.

"Matt is an outstanding researcher whose work touches on fundamental questions about how the cell machinery directs the synthesis and folding of proteins. His discoveries about how that machinery breaks down as a result of mutations or in response to stress has a fundamental impact on how we think about and treat human diseases," says Van Voorhis.

In one part of Shoulders' current research program, he is studying how protein folding systems in cells — known as chaperones — shape the evolution of their clients. Among other discoveries, his lab has shown that viral pathogens hijack human chaperones to enable their rapid evolution and escape from host immunity. In related recent work, they have discovered that these same chaperones can promote access to malignancy-driving mutations in tumors. Beyond fundamental insights into evolutionary biology, these findings hold potential to open new therapeutic strategies to target cancer and viral infections.

"Matt's ability to see both the details and the big picture makes him an outstanding researcher and a natural leader for the department," says Timothy Swager, the John D. MacArthur Professor of Chemistry. "MIT Chemistry can only benefit from his dedication to understanding and addressing the parts and the whole."

In addition to his research contributions, Shoulders has taught multiple classes for Course V, including 5.54 (Advances in Chemical Biology) and 5.111 (Principles of Chemical Science), along with a number of other key chemistry classes. His contributions to a 5.111 boot camp through the MITx platform served to address gaps in the classroom curriculum by providing online tools to help undergraduate students better grasp the material in the chemistry General Institute Requirement (GIR). His development of Guided Learning Demonstrations to support first-year chemistry courses at MIT has helped bring the lab to the GIR, and also contributed to the popularity of 5.111 courses offered regularly via MITx.

"I have had the pleasure of teaching with Matt on several occasions, and he is a fantastic educator. He is an innovator both inside and outside the classroom and has an unwavering commitment to his students' success," says Van Voorhis of Shoulders, who was named a 2022 MacVicar Faculty Fellow, and who received a Committed to Caring award through the Office of Graduate Education.

> **"We face challenges, but also many exciting opportunities, as a department in the years to come."**

Shoulders also founded the MIT Homeschool Internship Program for Science and Technology, which brings high school students to campus for paid summer research experiences in labs across the Institute.

He is a founding member of the Department of Chemistry's Quality of Life Committee and chair for the last six years, helping to improve all aspects of opportunity, professional development, and experience in the department: "countless changes that have helped make MIT a better place for all," as Van Voorhis notes, including creating a peer mentoring program for graduate students and establishing universal graduate student exit interviews to collect data for department-wide assessment and improvement.

At the Institute level, Shoulders has served on the Committee on Graduate Programs, Committee on Sexual Misconduct Prevention and Response (in which he co-chaired the provost's working group on the Faculty and Staff Sexual Misconduct Survey), and the Committee on Assessment of Biohazards and Embryonic Stem Cell Research Oversight, among other roles.

Shoulders graduated summa cum laude from Virginia Tech in 2004, earning a BS in chemistry with a minor in biochemistry. He earned a PhD in chemistry at the University of Wisconsin at Madison in 2009 under Professor Ronald Raines. Following an American Cancer Society Postdoctoral Fellowship at Scripps Research Institute, working with professors Jeffery Kelly and Luke Wiseman, Shoulders joined the MIT Department of Chemistry faculty as an assistant professor in 2012. Shoulders also serves as an associate member of the Broad Institute and an investigator at the Center for Musculoskeletal Research at Massachusetts General Hospital.

Among his many awards, Shoulders has received a NIH Director's New Innovator Award under the NIH High-Risk, High-Reward Research Program; an NSF CAREER Award; an American Cancer Society Research Scholar Award; the Camille Dreyfus Teacher-Scholar Award; and most recently the Ono Pharma Foundation Breakthrough Science Award.

MIT chemists boost the efficiency of a key enzyme in photosynthesis

The enzyme, known as rubisco, helps plants and photosynthetic bacteria incorporate carbon dioxide into sugars

Anne Trafton | MIT News

During photosynthesis, an enzyme called rubisco catalyzes a key reaction — the incorporation of carbon dioxide into organic compounds to create sugars. However, rubisco, which is believed to be the most abundant enzyme on Earth, is very inefficient compared to the other enzymes involved in photosynthesis.

MIT chemists have now shown that they can greatly enhance a version of rubisco found in bacteria from a low-oxygen environment. Using a process known as directed evolution — a technique in which a naturally occurring protein is randomly mutated and then screened for the emergence of new, desirable features — they identified mutations that could boost rubisco's catalytic efficiency by up to 25 percent.

The researchers now plan to apply their technique to forms of rubisco that could be used in plants to help boost their rates of photosynthesis, which could potentially improve crop yields.

"This is, I think, a compelling demonstration of successful improvement of a rubisco's enzymatic properties, holding out a lot of hope for engineering other forms of rubisco," says Matthew Shoulders, the Class of 1942 Professor of Chemistry at MIT.

Shoulders and Robert Wilson, a research scientist in the Department of Chemistry, are the senior authors of the new study, which appears this week in the *Proceedings of the National Academy of Sciences*. MIT graduate student Julie McDonald is the paper's lead author.

Using a process known as directed evolution, they identified mutations that could boost rubisco's catalytic efficiency by up to 25 percent.

Evolution of efficiency

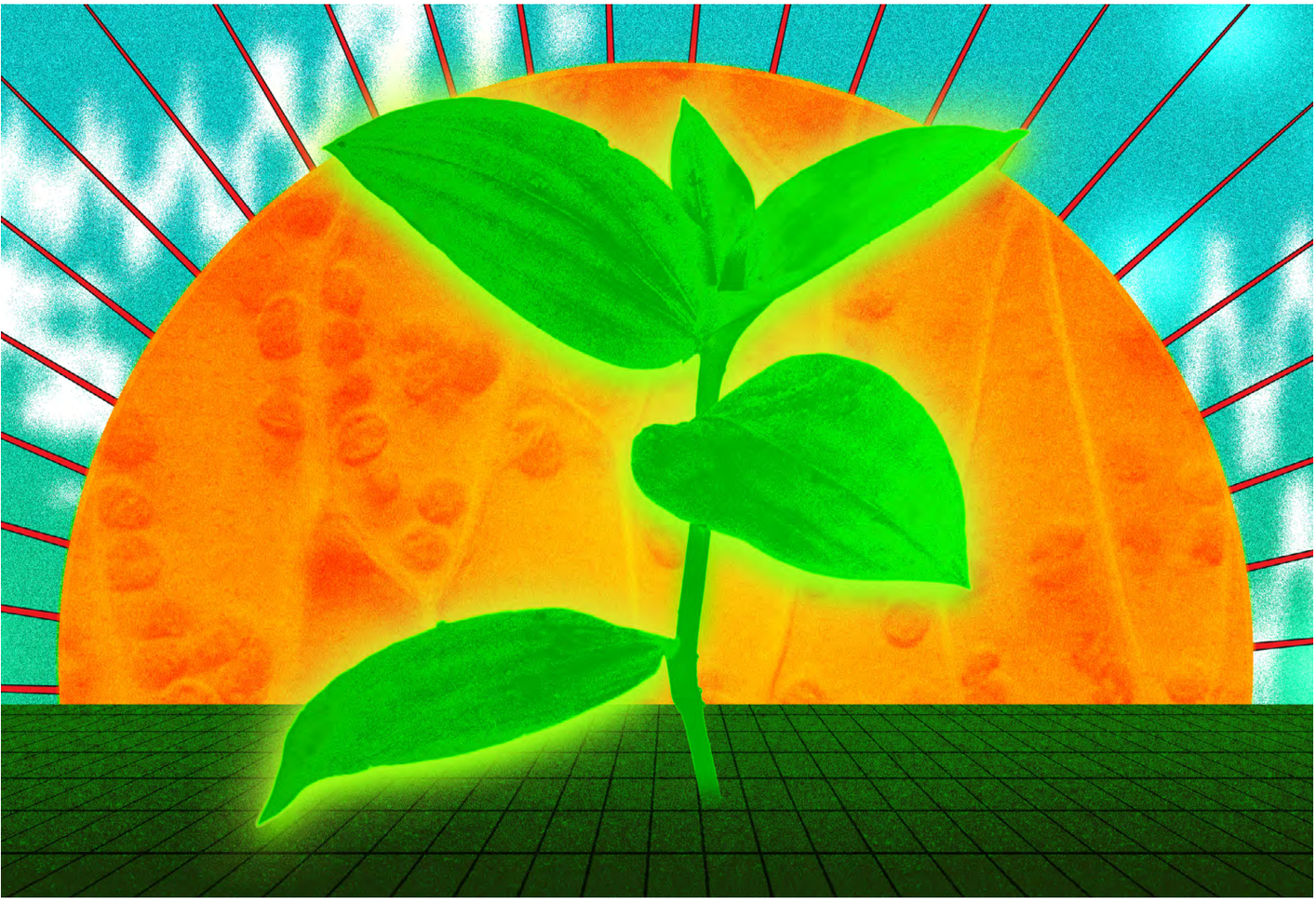
When plants or photosynthetic bacteria absorb energy from the sun, they first convert it into energy-storing molecules such as ATP. In the next phase of photosynthesis, cells use that energy to transform a molecule known as ribulose bisphosphate into glucose, which requires several additional reactions. Rubisco catalyzes the first of those reactions, known as carboxylation. During that reaction, carbon from CO_2 is added to ribulose bisphosphate.

Compared to the other enzymes involved in photosynthesis, rubisco is very slow, catalyzing only one to 10 reactions per second. Additionally, rubisco can also interact with oxygen, leading to a competing reaction that incorporates oxygen instead of carbon — a process that wastes some of the energy absorbed from sunlight.

"For protein engineers, that's a really attractive set of problems because those traits seem like things that you could hopefully make better by making changes to the enzyme's amino acid sequence," McDonald says.

Previous research has led to improvement in rubisco's stability and solubility, which resulted in small gains in enzyme efficiency. Most of those studies used directed evolution.

This process is usually done using error-prone PCR, a technique that first generates mutations in vitro (outside of the cell), typically introducing only one or two mutations in the target gene. In past studies on rubisco, this library of mutations was then introduced into bacteria that grow at a rate relative to rubisco activity. Limitations in error-prone PCR and in the efficiency of introducing new genes restrict the total number of mutations that can be generated and screened using this approach. Manual mutagenesis and selection steps also add more time to the process over multiple rounds of evolution.



MIT chemists have shown that they can greatly boost the efficiency of a bacterial version of rubisco, a key enzyme in photosynthesis.
Image: Jose-Luis Olivares/MIT

The MIT team instead used a newer mutagenesis technique that the Shoulders Lab previously developed, called MutaT7. This technique allows the researchers to perform both mutagenesis and screening in living cells, which dramatically speeds up the process. Their technique also enables them to mutate the target gene at a higher rate.

"Our continuous directed evolution technique allows you to look at a lot more mutations in the enzyme than has been done in the past," McDonald says.

Better rubisco

For this study, the researchers began with a version of rubisco, isolated from a family of semianaerobic bacteria known as *Gallionellaceae*, that is one of the fastest rubisco found in nature. During the directed evolution experiments, which were conducted in *E. coli*, the researchers kept the microbes in an environment with atmospheric levels of oxygen, creating evolutionary pressure to adapt to oxygen.

After six rounds of directed evolution, the researchers identified three different mutations that improved the rubisco's resistance to oxygen. Each of these mutations are located near the enzyme's active site (where it performs carboxylation or oxygenation). The researchers believe that these mutations improve the enzyme's ability to preferentially interact with carbon dioxide over oxygen, which leads to an overall increase in carboxylation efficiency.

"The underlying question here is: Can you alter and improve the kinetic properties of rubisco to operate better in environments where you want it to operate better?" Shoulders says. "What changed through the directed evolution process was that rubisco began to like to react with oxygen less. That allows this rubisco to function well in an oxygen-rich environment, where normally it would constantly get distracted and react with oxygen, which you don't want it to do."

In ongoing work, the researchers are applying this approach to other forms of rubisco, including rubisco from plants. Plants are believed to lose about 30 percent of the energy from the sunlight they absorb through a process called photorespiration, which occurs when rubisco acts on oxygen instead of carbon dioxide.

"This really opens the door to a lot of exciting new research, and it's a step beyond the types of engineering that have dominated rubisco engineering in the past," Wilson says. "There are definite benefits to agricultural productivity that could be leveraged through a better rubisco."

The research was funded, in part, by the National Science Foundation, the National Institutes of Health, an Abdul Latif Jameel Water and Food Systems Lab Grand Challenge grant, and a Martin Family Society Fellowship for Sustainability.

W. M. Keck Foundation to support research on healthy aging at MIT

Assistant Professor of Biology Alison Ringel will investigate the intersection of immunology and aging biology, aiming to define the mechanisms that underlie aging-related decline, thanks to grant from prestigious foundation

Lillian Eden | Department of Biology

A prestigious grant from the W. M. Keck Foundation to Assistant Professor of Biology Alison Ringel will support groundbreaking healthy aging research at MIT.

Ringel, also a core member of the Ragon Institute, will draw on her background in cancer immunology to create a more comprehensive biomedical understanding of the cause and possible treatments for aging-related decline.

"It is such an honor to receive this grant," Ringel says. "This support will enable us to draw new connections between immunology and aging biology. As the U.S. population grows older, advancing this research is increasingly important, and this line of inquiry is only possible because of the W. M. Keck Foundation."

Understanding how to extend healthy years of life is a fundamental question of biomedical research with wide-ranging societal implications. Although modern science and medicine have greatly expanded global life expectancy, it remains unclear why everyone ages differently; some maintain physical and cognitive fitness well into old age, while others become debilitatingly frail later in life.

Our immune systems are adaptable, but they do naturally decline as we get older. One critical component of our immune system is CD8+ T cells, which are known to target and destroy cancerous or damaged cells. As we age, our tissues accumulate cells that can no longer divide. These senescent cells are present throughout our lives, but reach seemingly harmful levels as a normal part of aging, causing tissue damage and diminished resilience under stress.

There is now compelling evidence that the immune system plays a more active role in aging than previously thought.

"Decades of research have revealed that T cells can eliminate cancer cells, and studies of how they do so have led directly to the development of cancer immunotherapy," Ringel says. "Building on these discoveries, we can now ask what roles T cells play in normal aging, where the accumulation of senescent cells, which are remarkably similar to cancer cells in some respects, may cause health problems later in life."

Alison Ringel, assistant professor of biology. *Photo: Raleigh McElvery*

In animal models, reconstituting elements of a young immune system has been shown to improve age-related decline, potentially due to CD8+ T cells selectively eliminating senescent cells. CD8+ T cells progressively losing the ability to cull senescent cells could explain some age-related pathology.

Ringel aims to build models for the express purpose of tracking and manipulating T cells in the context of aging and to evaluate how T cell behavior changes over a lifespan.

"By defining the protective processes that slow aging when we are young and healthy, and defining how these go awry in older adults, our goal is to generate knowledge that can be applied to extend healthy years of life," Ringel says. "I'm really excited about where this research can take us."

The W. M. Keck Foundation was established in 1954 in Los Angeles by William Myron Keck, founder of The Superior Oil Company. One of the nation's largest philanthropic organizations, the W. M. Keck Foundation supports outstanding science, engineering, and medical research. The foundation also supports undergraduate education and maintains a program within Southern California to support arts and culture, education, health and community service projects.

Alnylam Pharmaceuticals establishes named fund in honor of co-founder

The Phil Sharp–Alnylam Fund for Emerging Scientists will support graduate students and faculty in MIT Biology

Lillian Eden | Department of Biology

It's no question that graduate school in fundamental research was never for the faint of heart, but academia's nationwide funding disruptions threaten not just research happening now, but the critical pipeline for the next generation of scientists.

"What's keeping me up at night is the uncertainty," says Nobel Laureate Phillip A. Sharp, Institute Professor and professor of biology emeritus, and intramural faculty at the Koch Institute.

In the short term, Sharp foresees challenges in sustaining students so they can complete their degrees, postdoctoral scholars to finish their professional preparation, and faculty to set up and sustain their labs. In the long term, the impact becomes potentially existential — fewer people pursuing academia now means fewer advancements in the decades to come.

So, when Sharp was looped into discussions about a gift in his honor, he knew exactly where it should be directed. Established this year thanks to a generous donation from Alnylam Pharmaceuticals, the Phil Sharp–Alnylam Fund for Emerging Scientists will support graduate students and faculty within life sciences.

"This generosity by Alnylam provides an opportunity to bridge the uncertainty and ideally create the environment where students and others will feel that it's possible to do science and have a career," Sharp says.

The fund is set up to be flexible, so the expendable gift can be used to address the evolving needs of the Department of Biology, including financial support, research grants, and seed funding.

"This fund will help us fortify the department's capacity to train new generations of life science innovators and

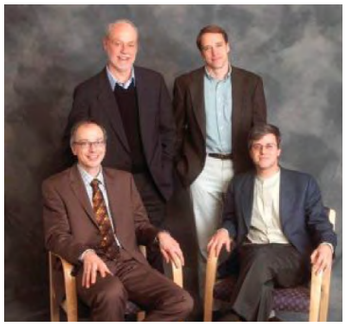
Institute Professor Phil Sharp. *Photo courtesy of the faculty*

leaders," says Amy E. Keating, department head and Jay A. Stein (1968) Professor of Biology and professor of biological engineering. "It is a great privilege for the department to be part of this recognition of Phil's key role at Alnylam."

Alnylam Pharmaceuticals, a company Sharp cofounded in 2002, is, in fact, a case study for the type of long-term investment in fundamental discovery that leads to paradigm-shifting strides in biomedical science, such as: what if the genetic drivers of diseases could be silenced by harnessing a naturally occurring gene regulation process?

Good things take time

In 1998, Andrew Fire PhD '83, who was trained as a graduate student in the Sharp Lab at MIT, and Craig Mello published a paper showing that double-stranded RNA suppresses the expression of the protein from the gene that encodes its sequence. The process, known as RNA interference, was such a groundbreaking revelation that Fire and Mello shared a Nobel Prize in Medicine and Physiology less than a decade later.



Four of the five co-founders of Alnylam Pharmaceuticals: (from left to right) Thomas Tuschl, Phillip Sharp, David Bartel, and Phil Zamore. Not pictured: Paul Schimmel. *Photo: Christoph Westphal*

RNAi is an innate cellular gene regulation process that can, for example, assist cells in defending against viruses by degrading viral RNA, thereby interfering with the production of viral proteins. Taking advantage of this natural process to fine-tune the expression of genes that encode specific proteins was a promising option for disease treatment, as many diseases are caused by the creation or buildup of mutated or faulty proteins. This approach would address the root cause of the disease, rather than its downstream symptoms.

The details of the biochemistry of RNAi were characterized and patented, and in 2002, Alnylam was founded by Sharp, David Bartel, Paul Schimmel, Thomas Tuschl, and Phillip Zamore.

"Sixteen years later, we got our first approval for a totally novel therapeutic agent to treat disease," Sharp says. "Something in a research laboratory, translated in about as short a time as you can do, gave rise to this whole new way of treating critical diseases."

This timeline isn't atypical. Particularly in health care, Sharp notes, investments often occur five or ten years before they come to fruition.

"Phil Sharp's visionary idea of harnessing RNAi to treat disease brought brilliant people together to pioneer this new class of medicines. RNAi therapeutics would not exist without the bridge Phil built between academia and industry. Now there are six approved Alnylam-discovered RNAi therapeutics, and we are exploring potential treatments for a range of rare and prevalent diseases to improve the lives of many more patients in need," says Kevin Fitzgerald, chief scientific officer of Alnylam Pharmaceuticals.

Today, the company has grown to over 2,500 employees, markets its six approved treatments worldwide, and has a long list of research programs that are likely to yield new therapeutic agents in the years to come.

Change is always on the horizon

Sharp foresees potential benefits for companies investing in academia, in the way Alnylam Pharmaceuticals has through the Phil Sharp–Alnylam Fund for Emerging Scientists.

"We are proud to support the MIT Department of Biology because investments in both early-stage and high-risk research have the potential to unlock the next wave of medical breakthroughs to help so many patients waiting for hope throughout the world," says Yvonne Greenstreet, chief executive officer of Alnylam Pharmaceuticals.

It is prudent for industry to keep its finger on the pulse — for becoming aware of new talent and for anticipating landscape-shifting advancements, such as artificial intelligence. Sharp notes that academia, in its pursuit of fundamental knowledge, "creates new ideas, new opportunities, and new ways of doing things."

"All of society, including biotech, is anticipating that AI is going to be a great accelerator," Sharp says. "Being associated with institutions that have great biology, chemistry, neuroscience, engineering, and computational innovation is how you sort through this anticipation of what the future is going to be."

But, Sharp says, it's a two-way street: academia should also be asking how it can best support the future workplaces for their students who will go on to have careers in industry. To that end, the Department of Biology recently launched a career connections initiative for current trainees to draw on the guidance and experience of alums, and to learn how to hone their knowledge so that they are a value-add to industry's needs.

"The symbiotic nature of these relationships is healthy for the country, and for society, all the way from basic research through innovative companies of all sizes, health care delivery, hospitals, and right down to primary care physicians meeting one-on-one with patients," Sharp says. "We're all part of that, and unless all parts of it remain healthy and appreciated, it will bode poorly for the future of the country's economy and well-being."

MIT joins in constructing the Giant Magellan Telescope

The major public-private partnership is expected to strengthen MIT research and U.S. leadership in astronomy and engineering

MIT is lending its support to the Giant Magellan Telescope, joining the international consortium to advance the $2.6 billion observatory in Chile. The Institute's participation, enabled by a transformational gift from philanthropists Phillip "Terry" Ragon '72 and Susan Ragon, adds to the momentum to construct the Giant Magellan Telescope, whose 25.4-meter aperture will have five times the light-collecting area and up to 200 times the power of existing observatories.

"As philanthropists, Terry and Susan have an unerring instinct for finding the big levers: those interventions that truly transform the scientific landscape," says MIT president Sally Kornbluth. "We saw this with their founding of the Ragon Institute, which pursues daring approaches to harnessing the immune system to prevent and cure human diseases. With [their] landmark gift, the Ragons enable an equally lofty mission to better understand the universe — and we could not be more grateful for their visionary support."

MIT will be the 16th member of the international consortium advancing the Giant Magellan Telescope and the 10th participant based in the United States. Together, the consortium has invested $1 billion in the observatory — the largest private investment in ground-based astronomy. The Giant Magellan Telescope is already 40 percent under construction, with major components being designed and manufactured across 36 U.S. states.

"MIT is honored to join the consortium and participate in this exceptional scientific endeavor," says Ian A. Waitz, MIT's vice president for research. "The Giant Magellan Telescope will bring tremendous new capabilities to MIT astronomy and to U.S. leadership in fundamental science. The construction of this uniquely powerful telescope represents a vital private and public investment in scientific excellence for decades to come."

MIT brings to the consortium powerful scientific capabilities and a legacy of astronomical excellence. MIT's departments of Physics and of Earth, Atmospheric and Planetary Sciences, and the MIT Kavli Institute for Astrophysics and Space Research, are internationally recognized for research in exoplanets, cosmology, and environments of extreme gravity, such as black holes and compact binary stars. MIT's involvement will strengthen the Giant Magellan Telescope's unique capabilities in high-resolution spectroscopy, adaptive optics, and the search for life beyond Earth. It also deepens a long-standing scientific relationship: MIT is already a partner in the existing twin Magellan Telescopes at Las Campanas Observatory in Chile — one of the most scientifically valuable observing sites on Earth, and the same site where the Giant Magellan Telescope is now under construction.

"Since Galileo's first spyglass, the world's largest telescope has doubled in aperture every 40 to 50 years," says Robert A. Simcoe, director of the MIT Kavli Institute and the Francis L. Friedman Professor of Physics. "Each generation's leading instruments have resolved important scientific questions of the day and then surprised their builders with new discoveries not yet even imagined, helping humans understand our place in the universe. Together with the Giant Magellan Telescope, MIT is helping to realize our generation's contribution to this lineage, consistent with our mission to advance the frontier of fundamental science by undertaking the most audacious and advanced engineering challenges."

Contributing to the national strategy

MIT's support comes at a pivotal time for the observatory. In June 2025, the National Science Foundation (NSF) advanced the Giant Magellan Telescope into its final

> "We are ... reinforcing the United States' position at the forefront of science."

design phase, one of the last steps before it becomes eligible for federal construction funding. To demonstrate readiness and a strong commitment to U.S. leadership, the consortium offered to privately fund this phase, which is traditionally supported by the NSF.

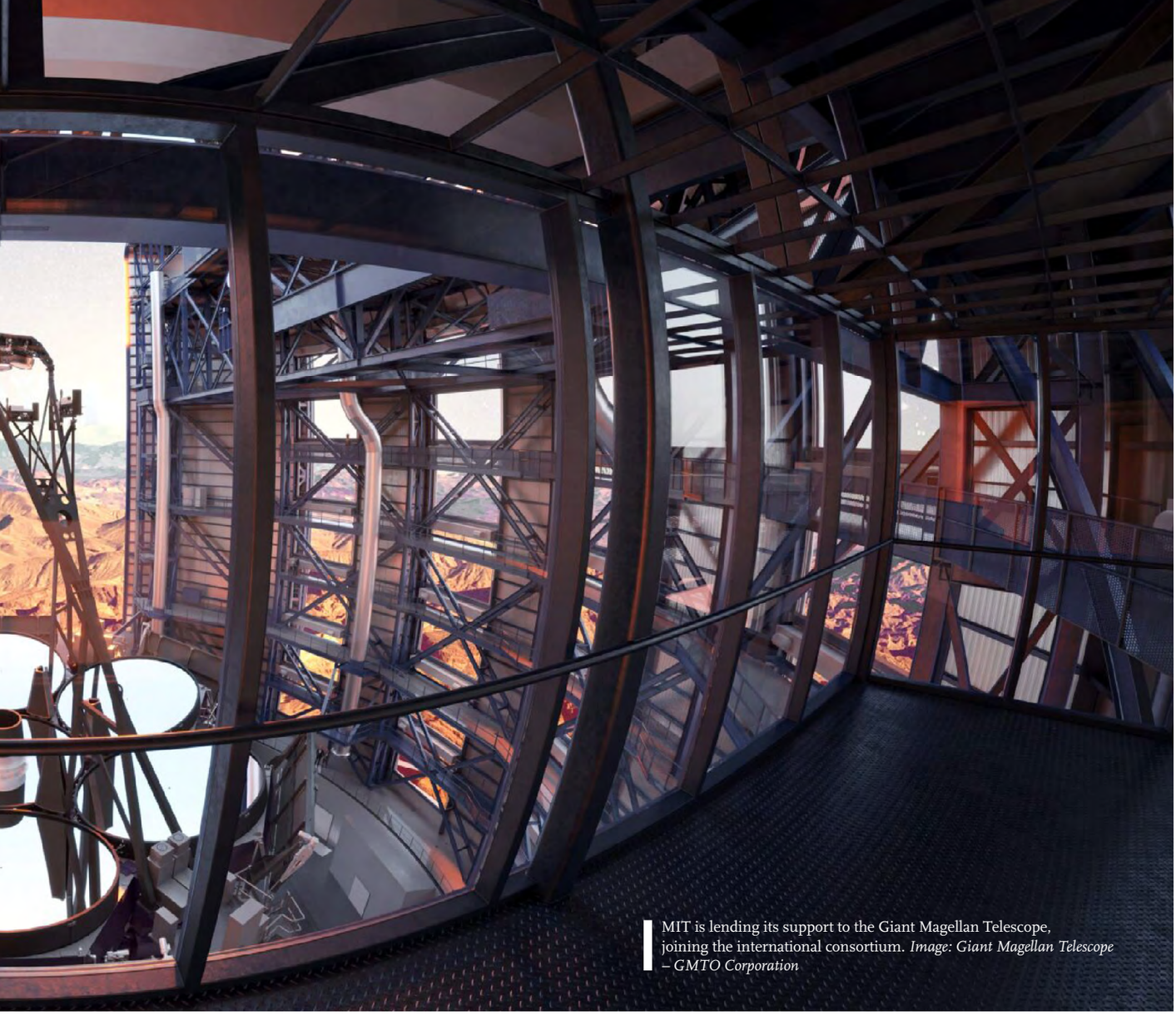
MIT's investment is an integral part of the national strategy to secure U.S. access to the next generation of research facilities known as "extremely large telescopes." The Giant Magellan Telescope is a core partner in the U.S. Extremely Large Telescope Program, the nation's top priority in astronomy. The National Academies' Astro2020 Decadal Survey called the program "absolutely essential if the United States is to maintain a position as a leader in ground-based astronomy." This long-term strategy also includes the recently commissioned Vera C. Rubin Observatory in Chile. Rubin is scanning the sky to detect rare, fast-changing cosmic events, while the Giant Magellan Telescope will provide the sensitivity, resolution, and spectroscopic instruments needed to study them in detail. Together, these southern hemisphere observatories will give U.S. scientists the tools they need to lead 21st-century astrophysics.

"Without direct access to the Giant Magellan Telescope, the U.S. risks falling behind in fundamental astronomy, as Rubin's most transformational discoveries will be utilized by other nations with access to their own 'extremely large telescopes' under development," says Walter E. Massey, board chair of the Giant Magellan Telescope.

MIT's participation brings the United States a step closer to completing the promise of this powerful new observatory on a globally competitive timeline. With federal construction funding, it is expected that the observatory could reach 90 percent completion in less than two years and become operational by the 2030s.

"MIT brings critical expertise and momentum at a time when global leadership in astronomy hangs in the balance," says Robert Shelton, president of the Giant Magellan Telescope. "With MIT, we are not just adding a partner; we are accelerating a shared vision for the future and reinforcing the United States' position at the forefront of science."

Other members of the Giant Magellan Telescope consortium include the University of Arizona, Carnegie Institution for Science, University of Texas at Austin, Korea Astronomy and Space Science Institute, University of Chicago, São Paulo Research Foundation, Texas A&M University, Northwestern University, Harvard University,



MIT is lending its support to the Giant Magellan Telescope, joining the international consortium. *Image: Giant Magellan Telescope – GMTO Corporation*

Astronomy Australia Ltd., Australian National University, Smithsonian Institution, Weizmann Institute of Science, Academia Sinica Institute of Astronomy and Astrophysics, and Arizona State University.

A boon for astrophysics research and education

Access to the world's best optical telescopes is a critical resource for MIT researchers. More than 150 individual science programs at MIT have relied on major astronomical observatories in the past three years, engaging faculty, researchers, and students in investigations into the marvels of the universe. Recent research projects have included chemical studies of the universe's oldest stars, led by Professor Anna Frebel; spectroscopy of stars shredded by dormant black holes, led by Professor Erin Kara; and measurements of a white dwarf teetering on the precipice of a black hole, led by Professor Kevin Burdge.

"Over many decades, researchers at the MIT Kavli Institute have used unparalleled instruments to discover previously undetected cosmic phenomena from both ground-based observations and spaceflight missions," says Nergis Mavalvala, dean of the MIT School of Science and the Curtis (1963) and Kathleen Marble Professor of Astrophysics. "I have no doubt our brilliant colleagues will carry on that tradition with the Giant Magellan Telescope, and I can't wait to see what they will discover next."

The Giant Magellan Telescope will also provide a platform for advanced R&D in remote sensing, creating opportunities to build custom infrared and optical spectrometers and high-speed imagers to further study our universe.

"One cannot have a leading physics program without a leading astrophysics program. Access to time on the Giant Magellan Telescope will ensure that future generations of MIT researchers will continue to work at the forefront of astrophysical discovery for decades to come," says Deepto Chakrabarty, head of the MIT Department of Physics, the William A. M. Burden Professor in Astrophysics, and principal investigator at the MIT Kavli Institute. "Our institutional access will help attract and retain top researchers in astrophysics, planetary science, and advanced optics, and will give our PhD students and postdocs unrivaled educational opportunities."

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